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(54) **Support system for the failure analysis of a plant**

(57) The analysis of any failure in a plant is supported by displaying the position of a point causing the failure, the situation of the failure and a method of coping with the failure. A monitoring mend 70a displays the name of the constituent system of the plant in a background color which corresponds to the degree of the failure. A system diagram display image 70b displays the name of the device of the constituent system in a background color which corresponds to the degree of the failure. A device information supplying image 70c, which contains the explanation of the pertinent device and the method of coping with the failure, is displayed in response to the touch of a system operator with the device name display area 11 of the system diagram display image 70b. Also, the trend graph of the state variable of the pertinent device is displayed in response to the touch of the system operator with the state variable display area 17 of the system diagram display image 70b. Further, in a case where a trip has occurred, the information thereof is saved, and it can be displayed in a trip data image 70e.

FIG.7

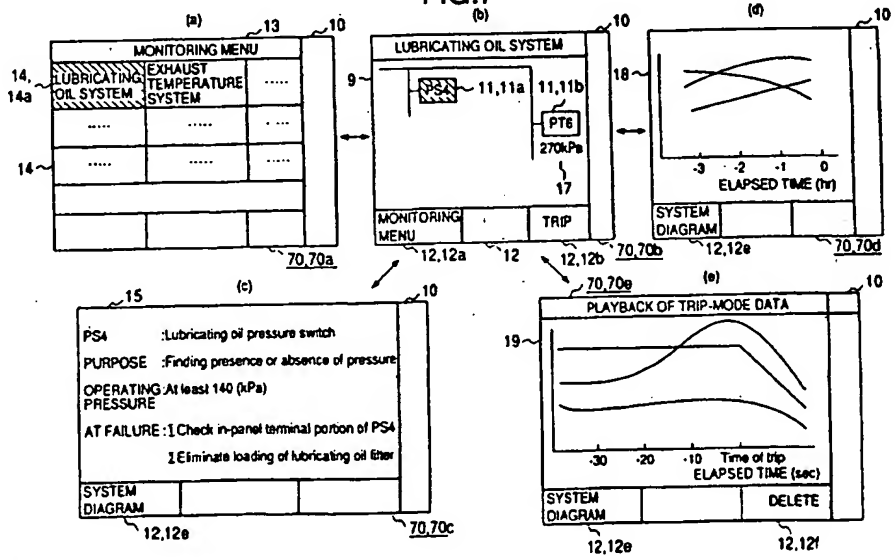

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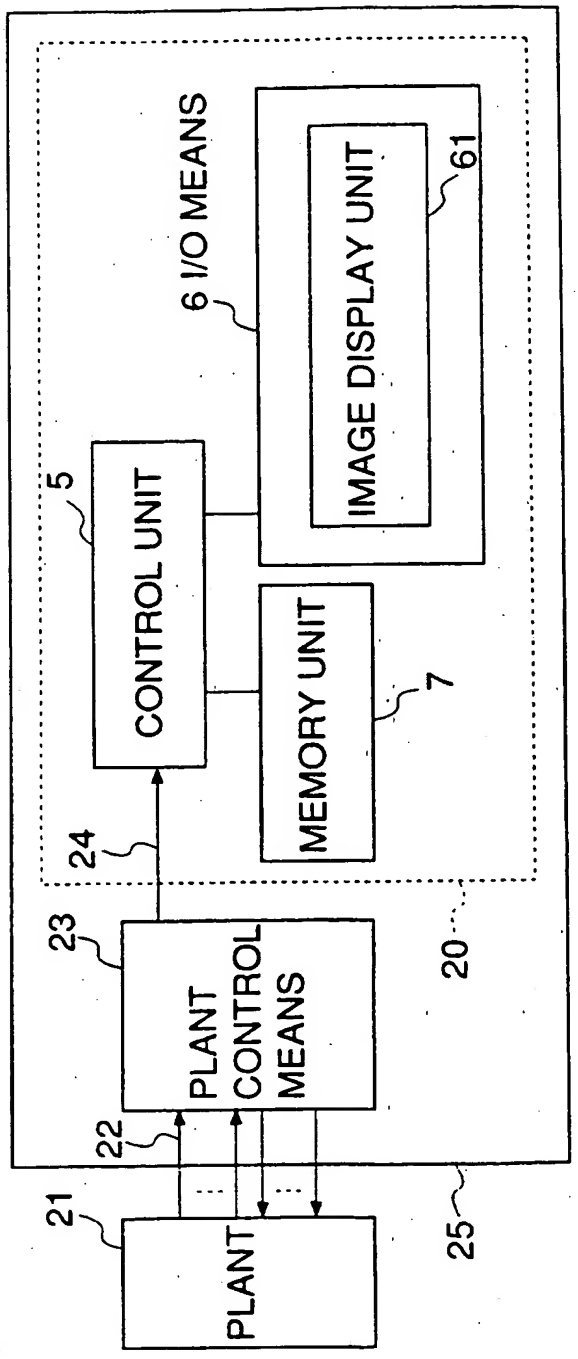
FIG.1


PLANT
21
22
PLANT CONTROL MEANS
23
24
CONTROL UNIT
5
MEMORY UNIT
7
6 I/O MEANS
IMAGE DISPLAY UNIT
61
20
25

PRIOR ART

FIG.2

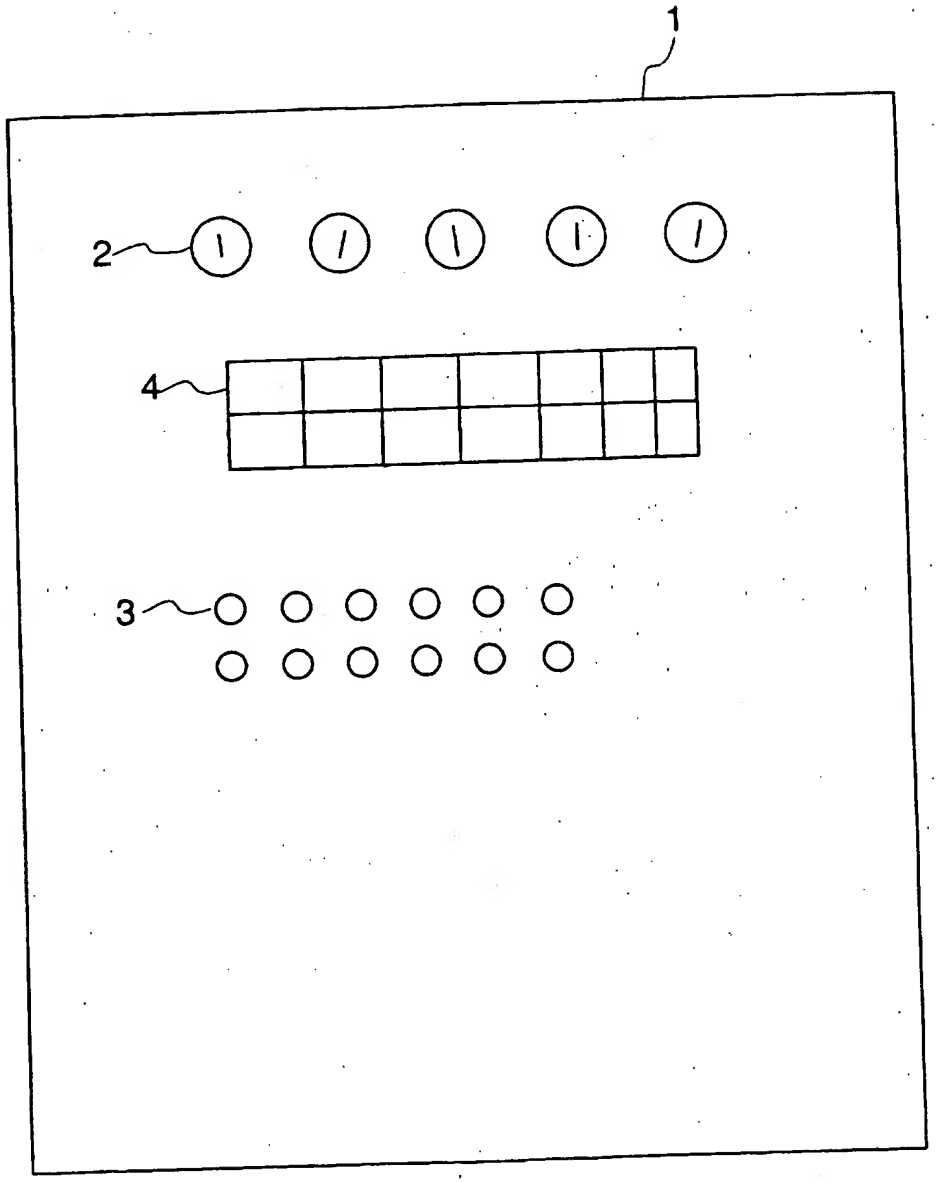


FIG.3

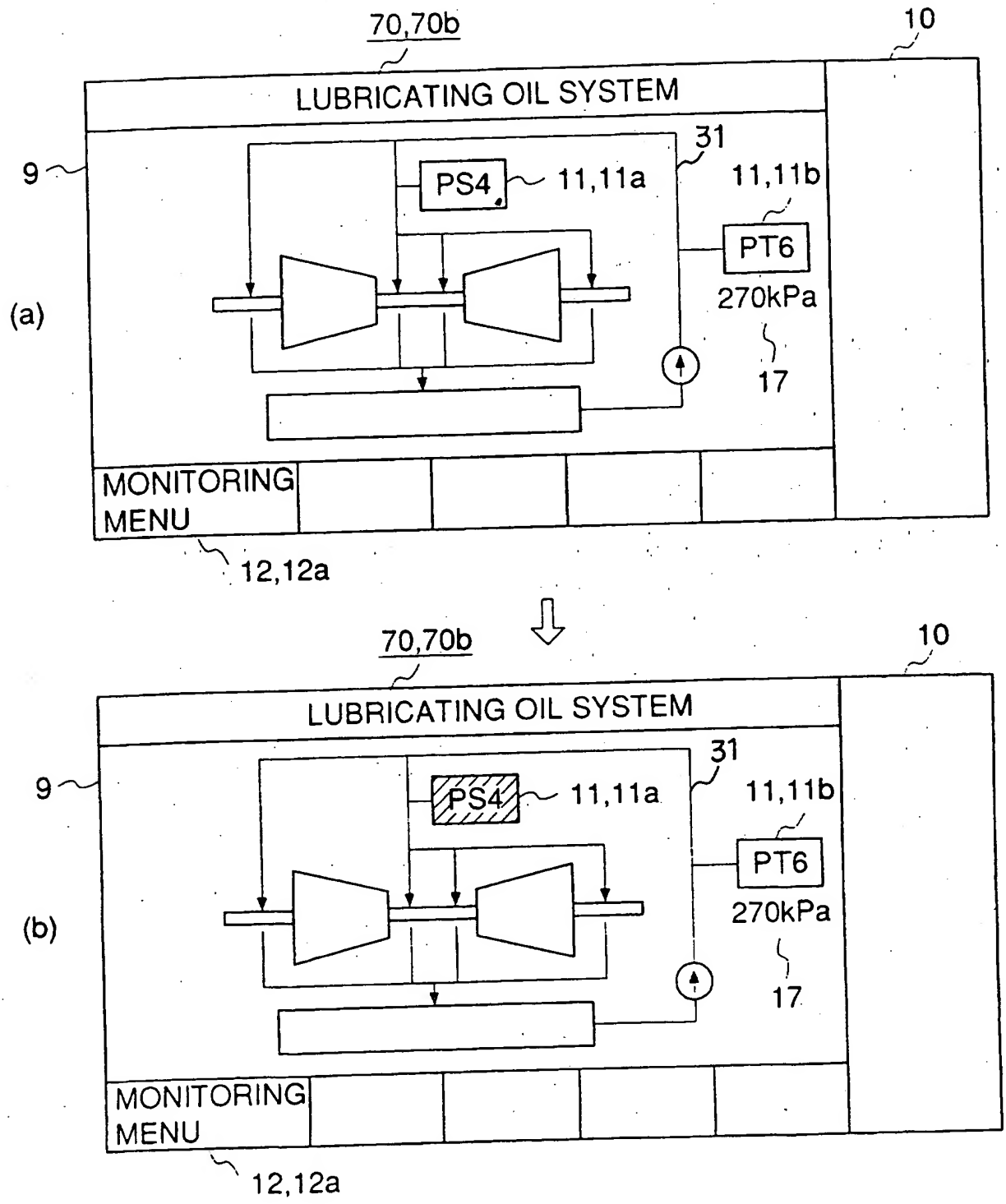

70,70b
10
LUBRICATING OIL SYSTEM
9
31
PS4
11,11a
11,11b
PT6
270kPa
17
(a)
MONITORING MENU
12,12a
70,70b
10
LUBRICATING OIL SYSTEM
9
31
PS4
11,11a
11,11b
PT6
270kPa
17
(b)
MONITORING MENU
12,12a

FIG.4

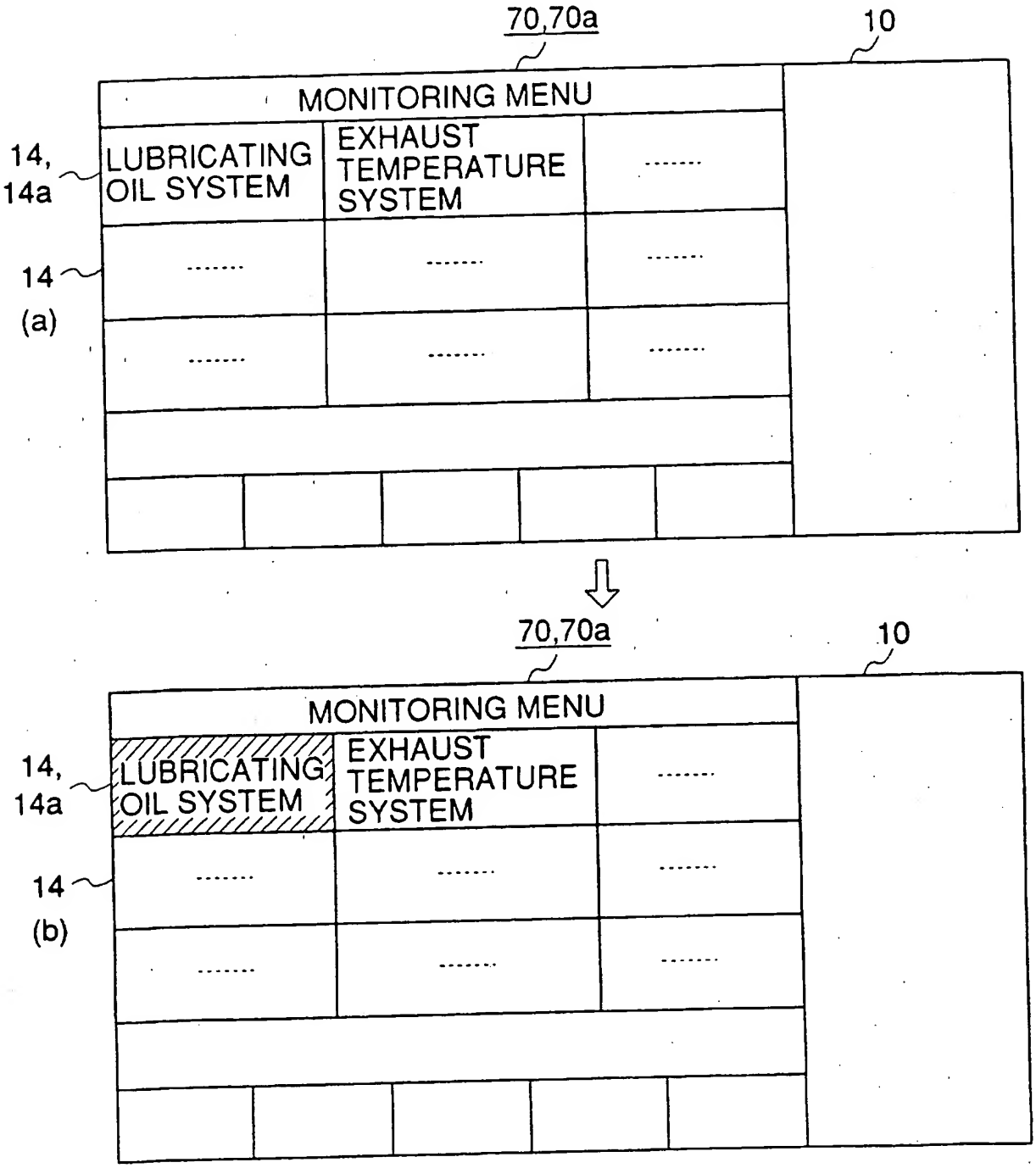

70,70a
10
MONITORING MENU
14, 14a
LUBRICATING OIL SYSTEM
EXHAUST TEMPERATURE SYSTEM
.....
14
(a)
70,70a
10
MONITORING MENU
14, 14a
LUBRICATING OIL SYSTEM
EXHAUST TEMPERATURE SYSTEM
.....
14
(b)

FIG.5

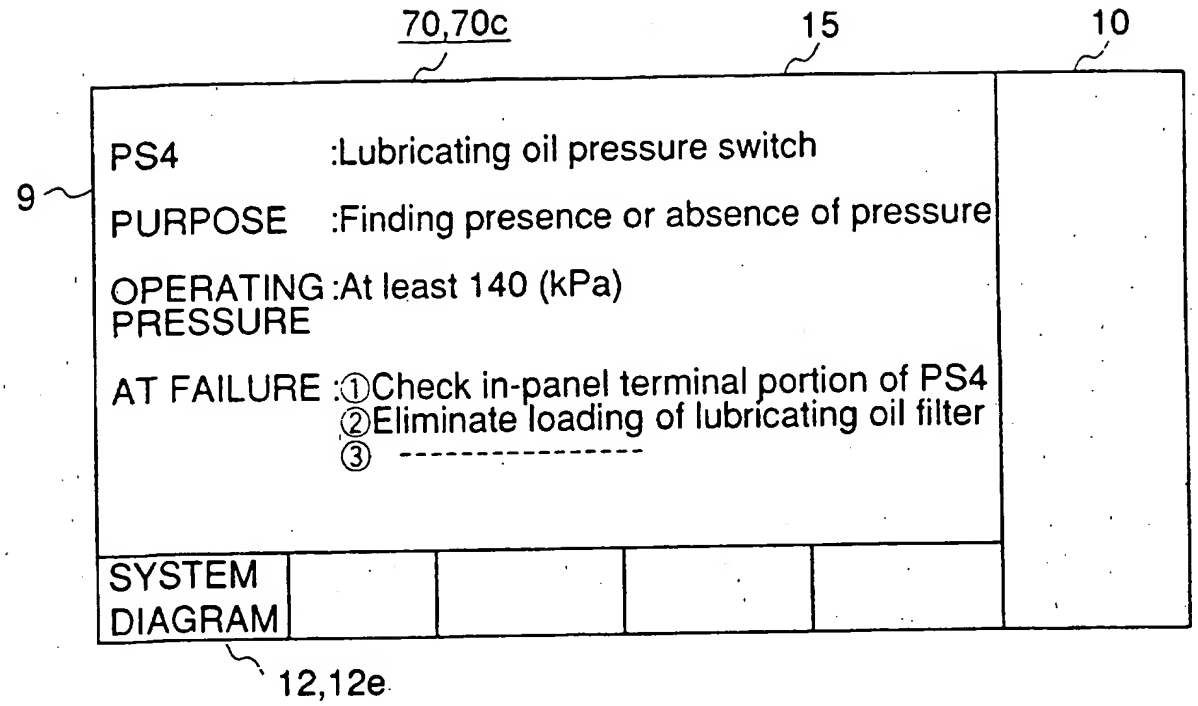

70,70c
15
10
9
PS4 :Lubricating oil pressure switch
PURPOSE :Finding presence or absence of pressure
OPERATING PRESSURE :At least 140 (kPa)
AT FAILURE :①Check in-panel terminal portion of PS4
②Eliminate loading of lubricating oil filter
③ ----------
SYSTEM DIAGRAM
12,12e

FIG.6

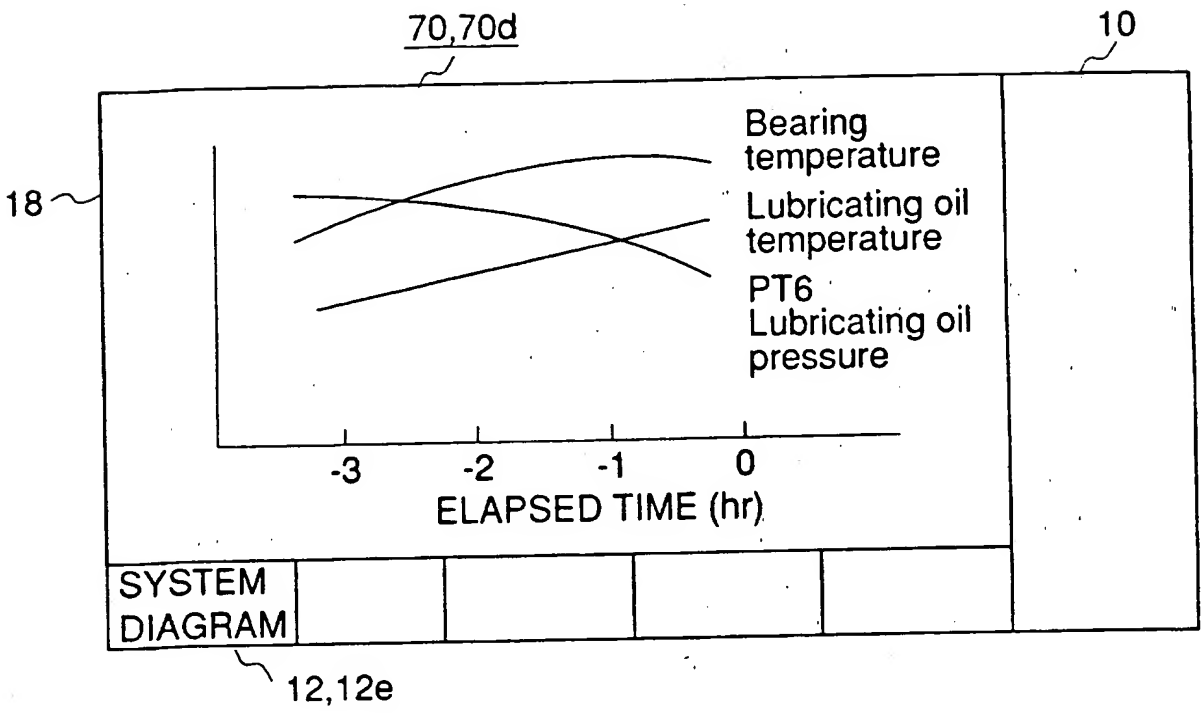

70,70d
10
18
Bearing temperature
Lubricating oil temperature
PT6 Lubricating oil pressure
-3
-2
-1
0
ELAPSED TIME (hr)
SYSTEM DIAGRAM
12,12e

FIG.7

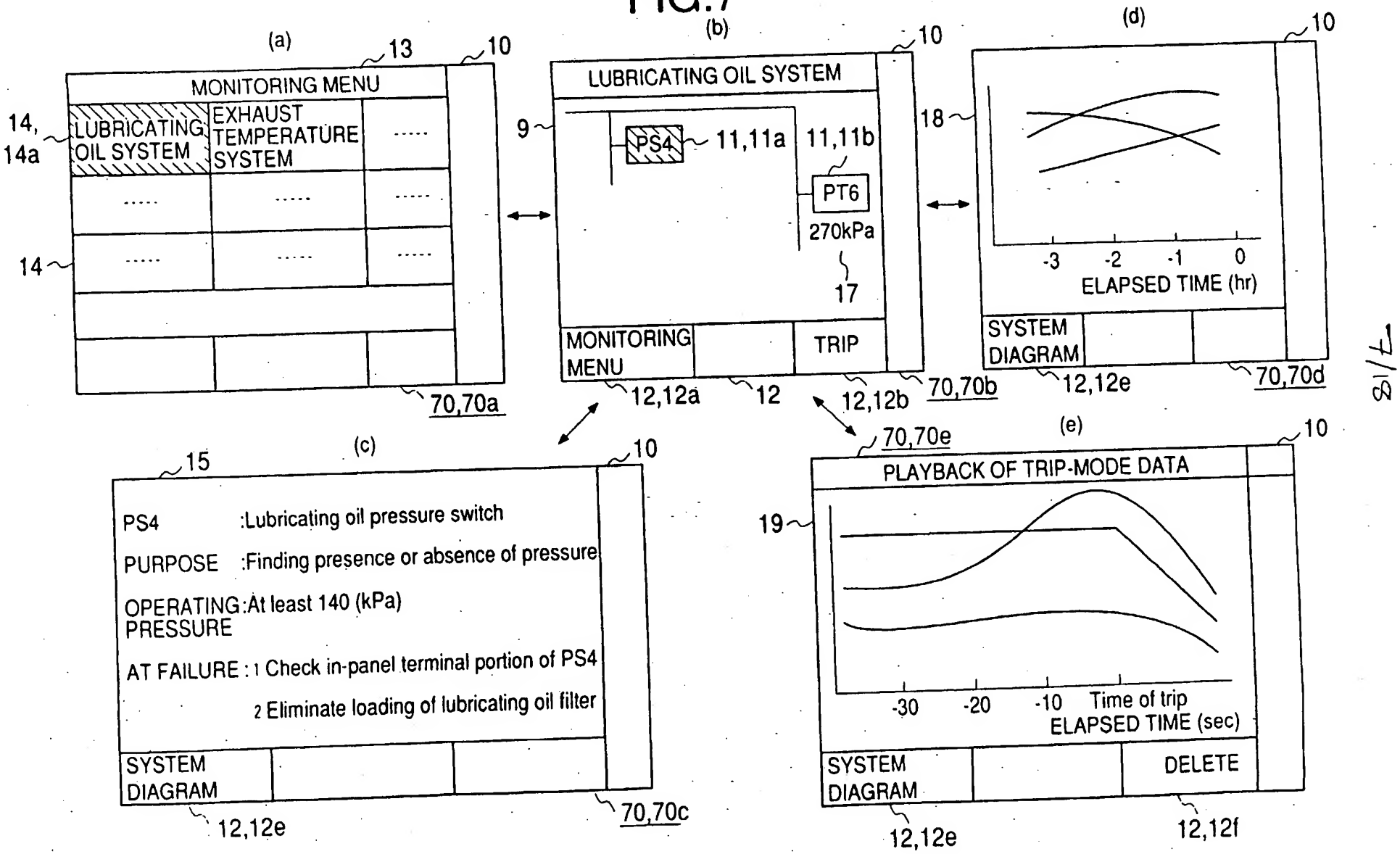

(a)
13
10
MONITORING MENU
14, 14a
LUBRICATING OIL SYSTEM
EXHAUST TEMPERATURE SYSTEM
14
70,70a
(b)
10
LUBRICATING OIL SYSTEM
9
PS4
11,11a
11,11b
PT6
270kPa
17
MONITORING MENU
TRIP
12,12a
12
12,12b
70,70b
(d)
10
18
-3
-2
-1
0
ELAPSED TIME (hr)
SYSTEM DIAGRAM
12,12e
70,70d
(c)
15
10
PS4 :Lubricating oil pressure switch
PURPOSE :Finding presence or absence of pressure
OPERATING PRESSURE :At least 140 (kPa)
AT FAILURE : 1 Check in-panel terminal portion of PS4
2 Eliminate loading of lubricating oil filter
SYSTEM DIAGRAM
12,12e
70,70c
70,70e
(e)
10
PLAYBACK OF TRIP-MODE DATA
19
-30
-20
-10
Time of trip
ELAPSED TIME (sec)
SYSTEM DIAGRAM
DELETE
12,12e
12,12f

FIG.8

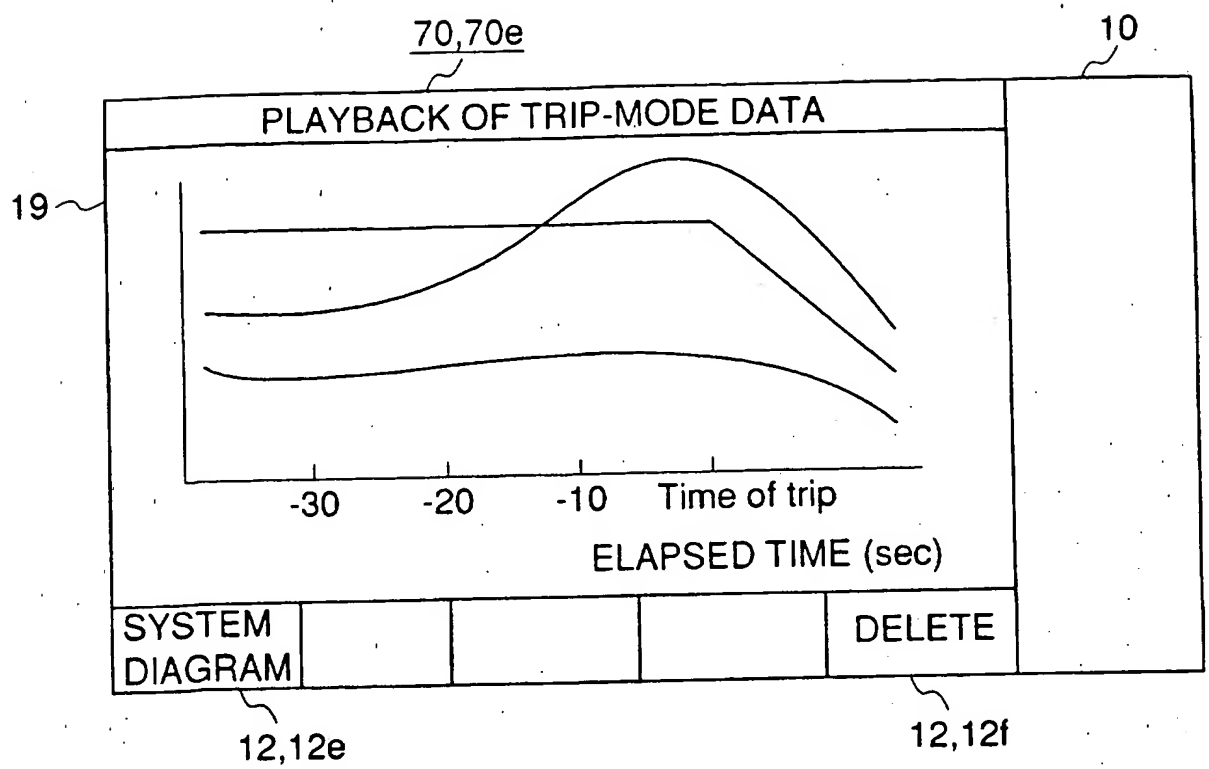

70,70e
10
PLAYBACK OF TRIP-MODE DATA
19
-30
-20
-10
Time of trip
ELAPSED TIME (sec)
SYSTEM DIAGRAM
DELETE
12,12e
12,12f

FIG.9

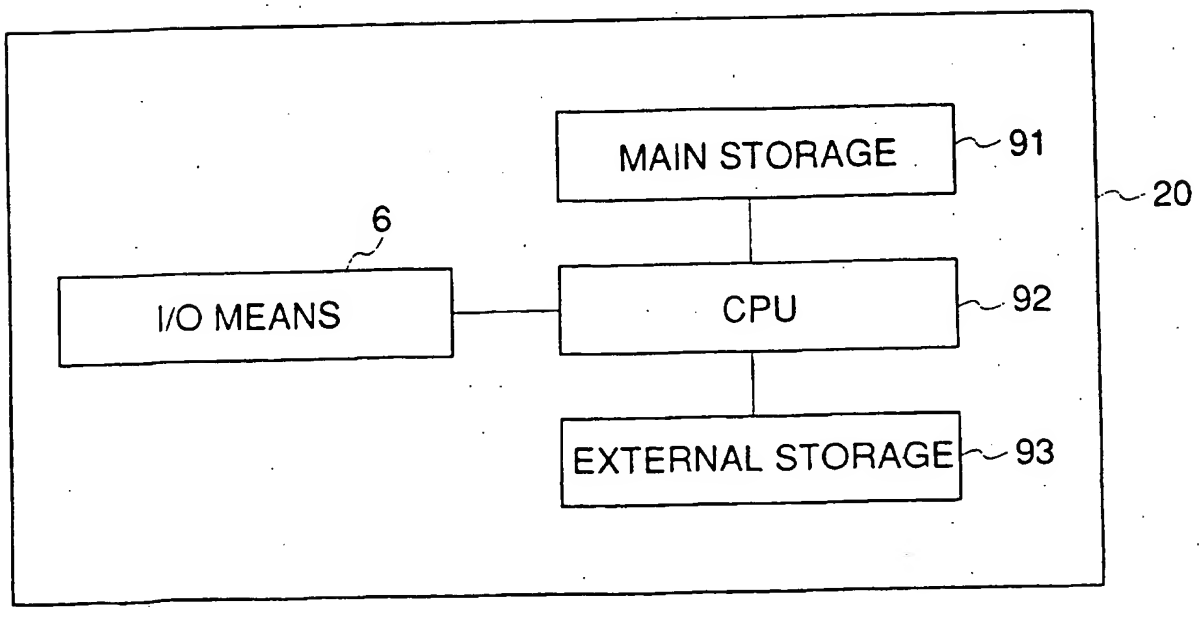

MAIN STORAGE
91
20
6
I/O MEANS
CPU
92
EXTERNAL STORAGE
93

FIG.10

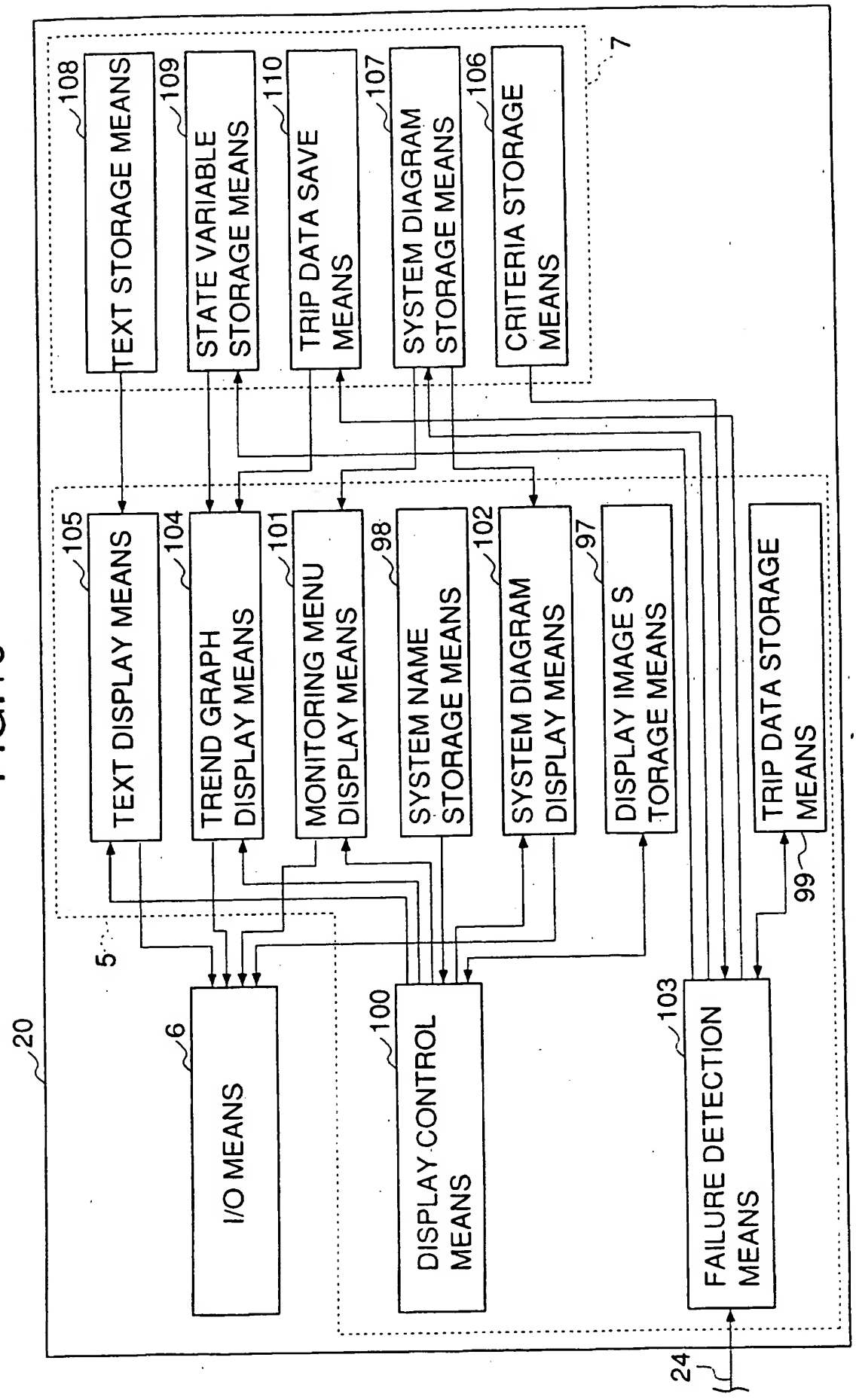

20
7
108
TEXT STORAGE MEANS
109
STATE VARIABLE STORAGE MEANS
110
TRIP DATA SAVE MEANS
107
SYSTEM DIAGRAM STORAGE MEANS
106
CRITERIA STORAGE MEANS
105
TEXT DISPLAY MEANS
104
TREND GRAPH DISPLAY MEANS
101
MONITORING MENU DISPLAY MEANS
98
SYSTEM NAME STORAGE MEANS
102
SYSTEM DIAGRAM DISPLAY MEANS
97
DISPLAY IMAGE S TORAGE MEANS
99
TRIP DATA STORAGE MEANS
5
6
I/O MEANS
100
DISPLAY CONTROL MEANS
103
FAILURE DETECTION MEANS
24

FIG.11

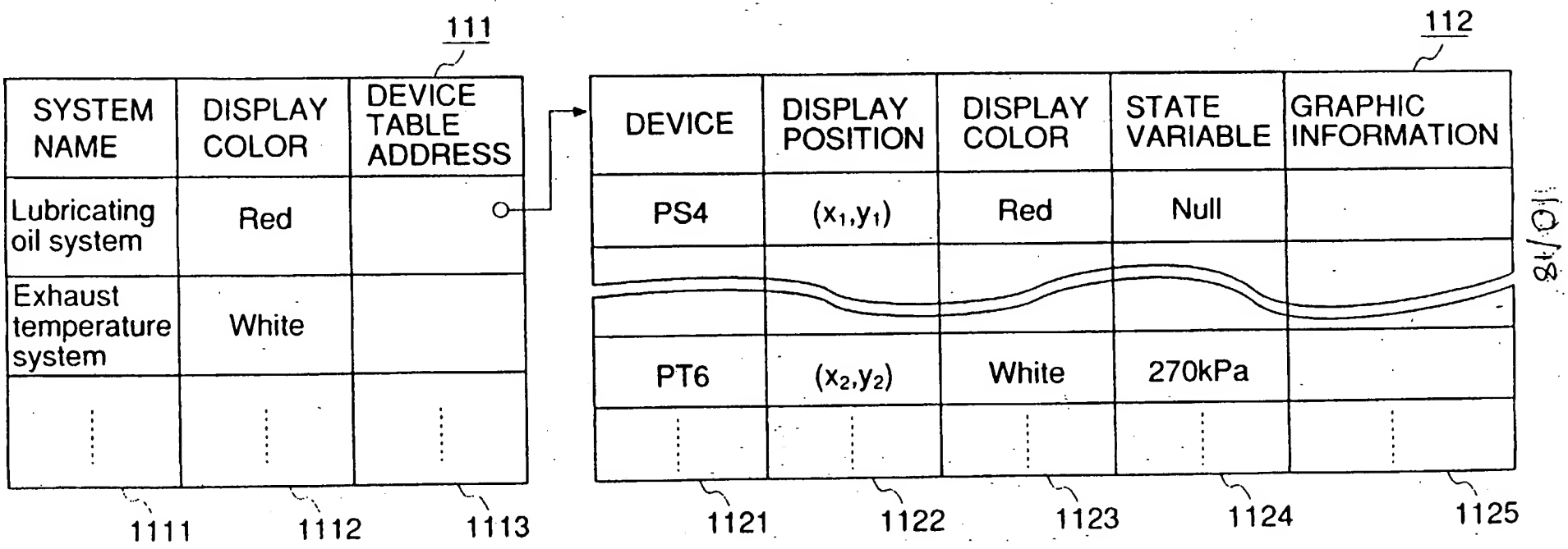

111
SYSTEM NAME
DISPLAY COLOR
DEVICE TABLE ADDRESS
Lubricating oil system
Red
Exhaust temperature system
White
1111
1112
1113
112
DEVICE
DISPLAY POSITION
DISPLAY COLOR
STATE VARIABLE
GRAPHIC INFORMATION
PS4
(x_1,y_1)
Red
Null
PT6
(x_2,y_2)
White
270kPa
1121
1122
1123
1124
1125

FIG.12

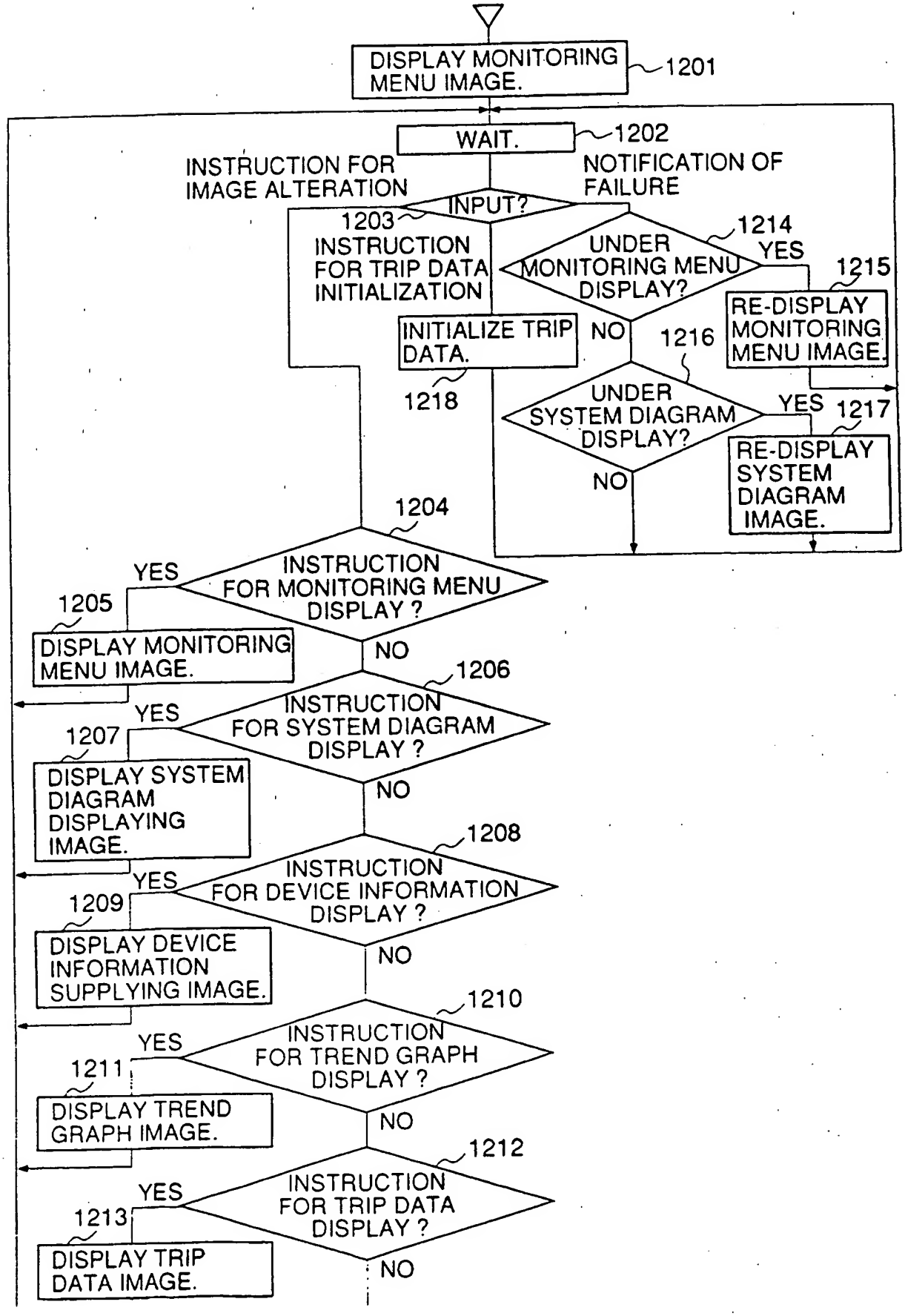

DISPLAY MONITORING MENU IMAGE.
1201
WAIT.
1202
INSTRUCTION FOR IMAGE ALTERATION
NOTIFICATION OF FAILURE
INPUT?
1203
INSTRUCTION FOR TRIP DATA INITIALIZATION
INITIALIZE TRIP DATA.
1218
1214
UNDER MONITORING MENU DISPLAY?
YES
1215
RE-DISPLAY MONITORING MENU IMAGE.
NO
1216
UNDER SYSTEM DIAGRAM DISPLAY?
YES
1217
RE-DISPLAY SYSTEM DIAGRAM IMAGE.
NO
1204
INSTRUCTION FOR MONITORING MENU DISPLAY ?
YES
1205
DISPLAY MONITORING MENU IMAGE.
NO
1206
INSTRUCTION FOR SYSTEM DIAGRAM DISPLAY ?
YES
1207
DISPLAY SYSTEM DIAGRAM DISPLAYING IMAGE.
NO
1208
INSTRUCTION FOR DEVICE INFORMATION DISPLAY ?
YES
1209
DISPLAY DEVICE INFORMATION SUPPLYING IMAGE.
NO
1210
INSTRUCTION FOR TREND GRAPH DISPLAY ?
YES
1211
DISPLAY TREND GRAPH IMAGE.
NO
1212
INSTRUCTION FOR TRIP DATA DISPLAY ?
YES
1213
DISPLAY TRIP DATA IMAGE.
NO

FIG.13

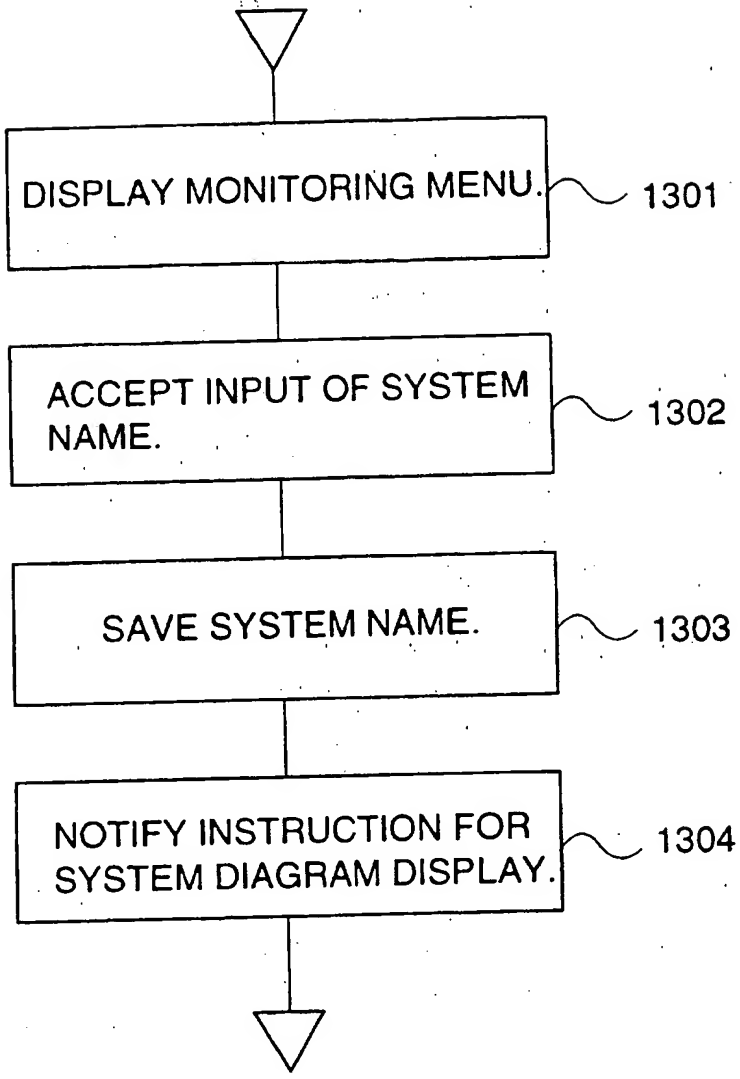

DISPLAY MONITORING MENU.
1301
ACCEPT INPUT OF SYSTEM NAME.
1302
SAVE SYSTEM NAME.
1303
NOTIFY INSTRUCTION FOR SYSTEM DIAGRAM DISPLAY.
1304

FIG.14

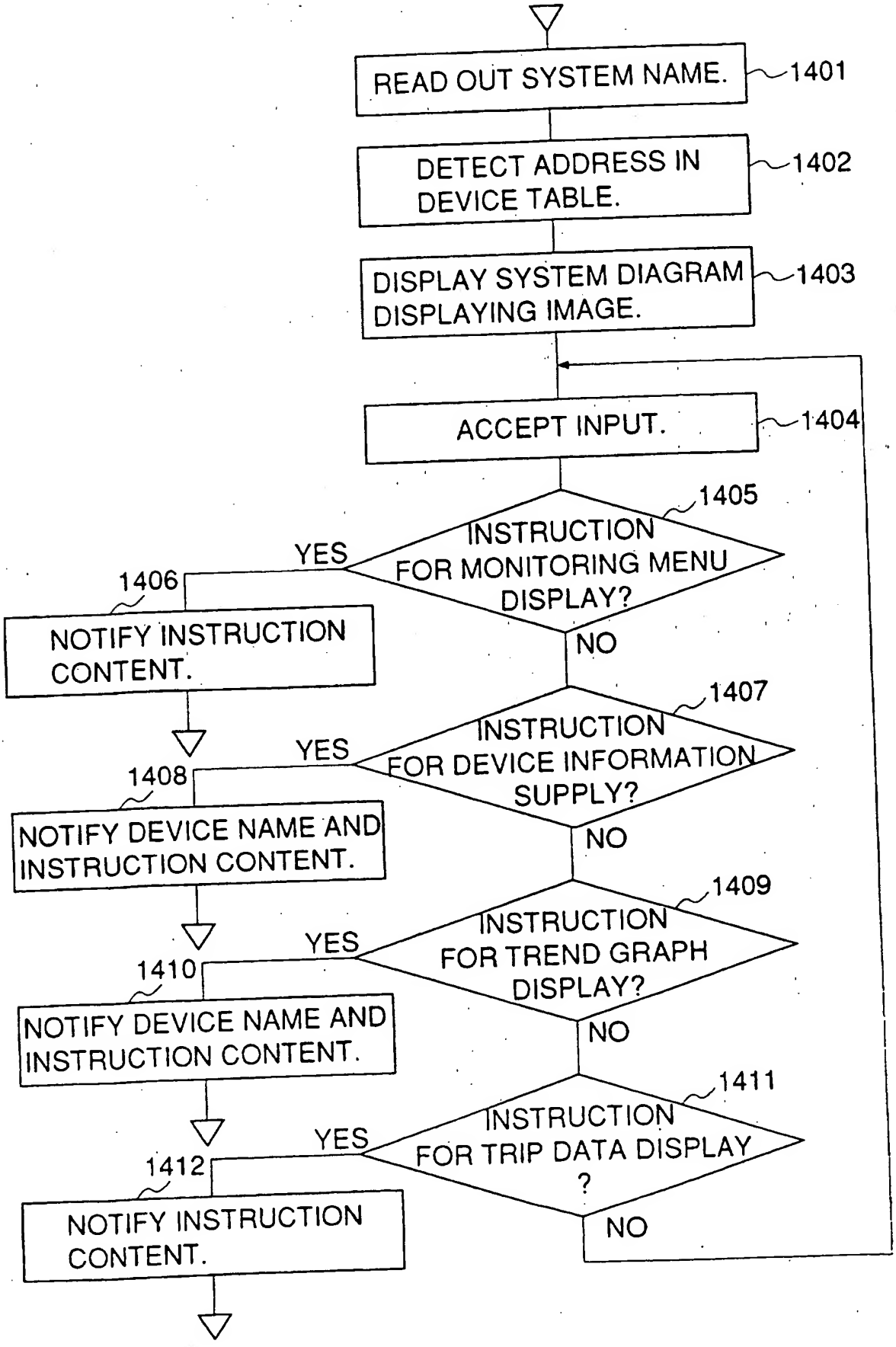

READ OUT SYSTEM NAME.
1401
DETECT ADDRESS IN DEVICE TABLE.
1402
DISPLAY SYSTEM DIAGRAM DISPLAYING IMAGE.
1403
ACCEPT INPUT.
1404
1405
INSTRUCTION FOR MONITORING MENU DISPLAY?
YES
NO
1406
NOTIFY INSTRUCTION CONTENT.
1407
INSTRUCTION FOR DEVICE INFORMATION SUPPLY?
YES
NO
1408
NOTIFY DEVICE NAME AND INSTRUCTION CONTENT.
1409
INSTRUCTION FOR TREND GRAPH DISPLAY?
YES
NO
1410
NOTIFY DEVICE NAME AND INSTRUCTION CONTENT.
1411
INSTRUCTION FOR TRIP DATA DISPLAY ?
YES
NO
1412
NOTIFY INSTRUCTION CONTENT.

FIG.15

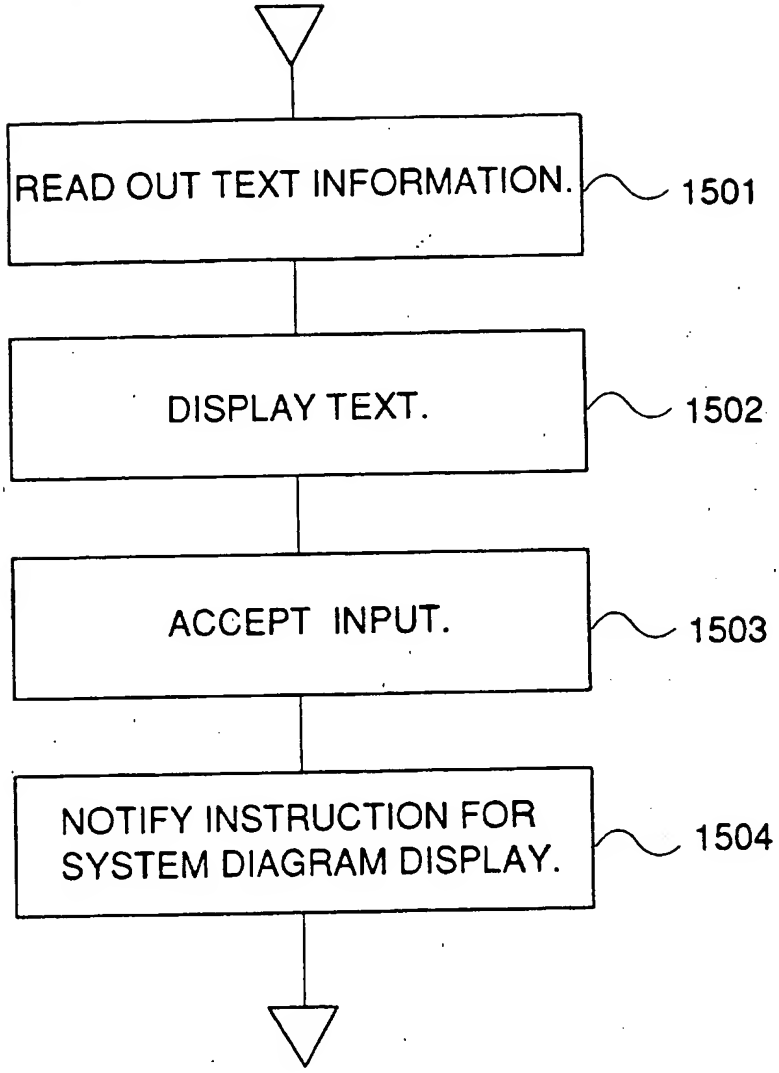

READ OUT TEXT INFORMATION.
1501
DISPLAY TEXT.
1502
ACCEPT INPUT.
1503
NOTIFY INSTRUCTION FOR SYSTEM DIAGRAM DISPLAY.
1504

FIG.16

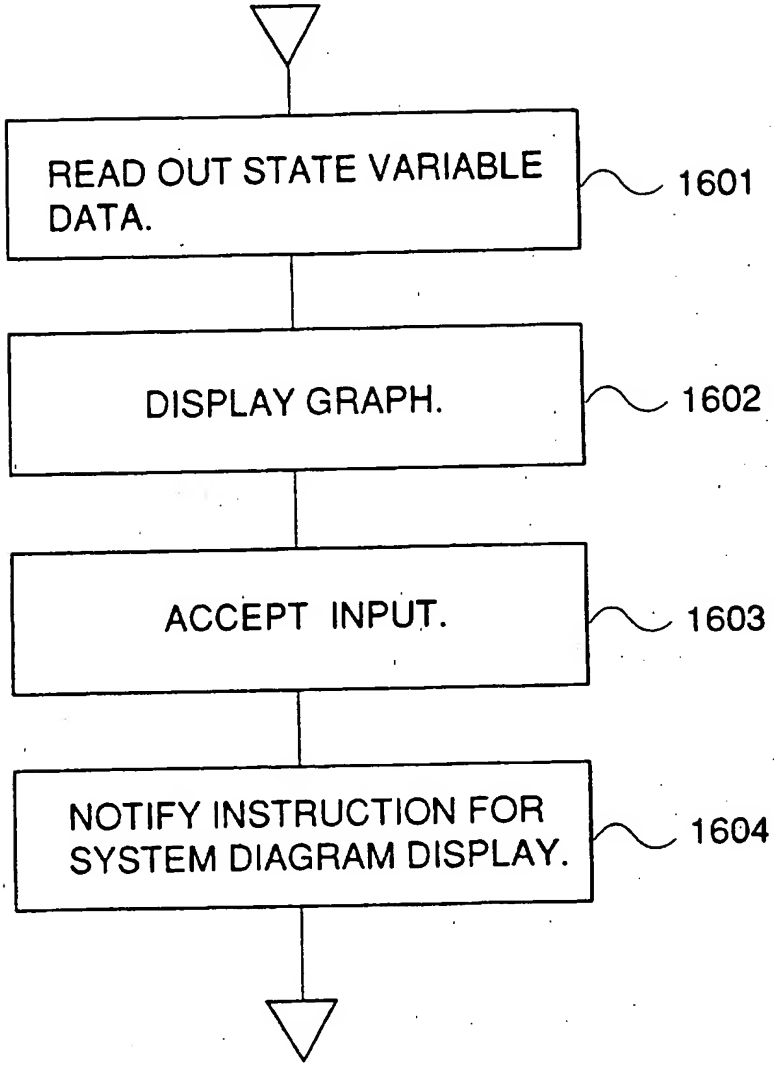

READ OUT STATE VARIABLE DATA.
1601
DISPLAY GRAPH.
1602
ACCEPT INPUT.
1603
NOTIFY INSTRUCTION FOR SYSTEM DIAGRAM DISPLAY.
1604

FIG.17

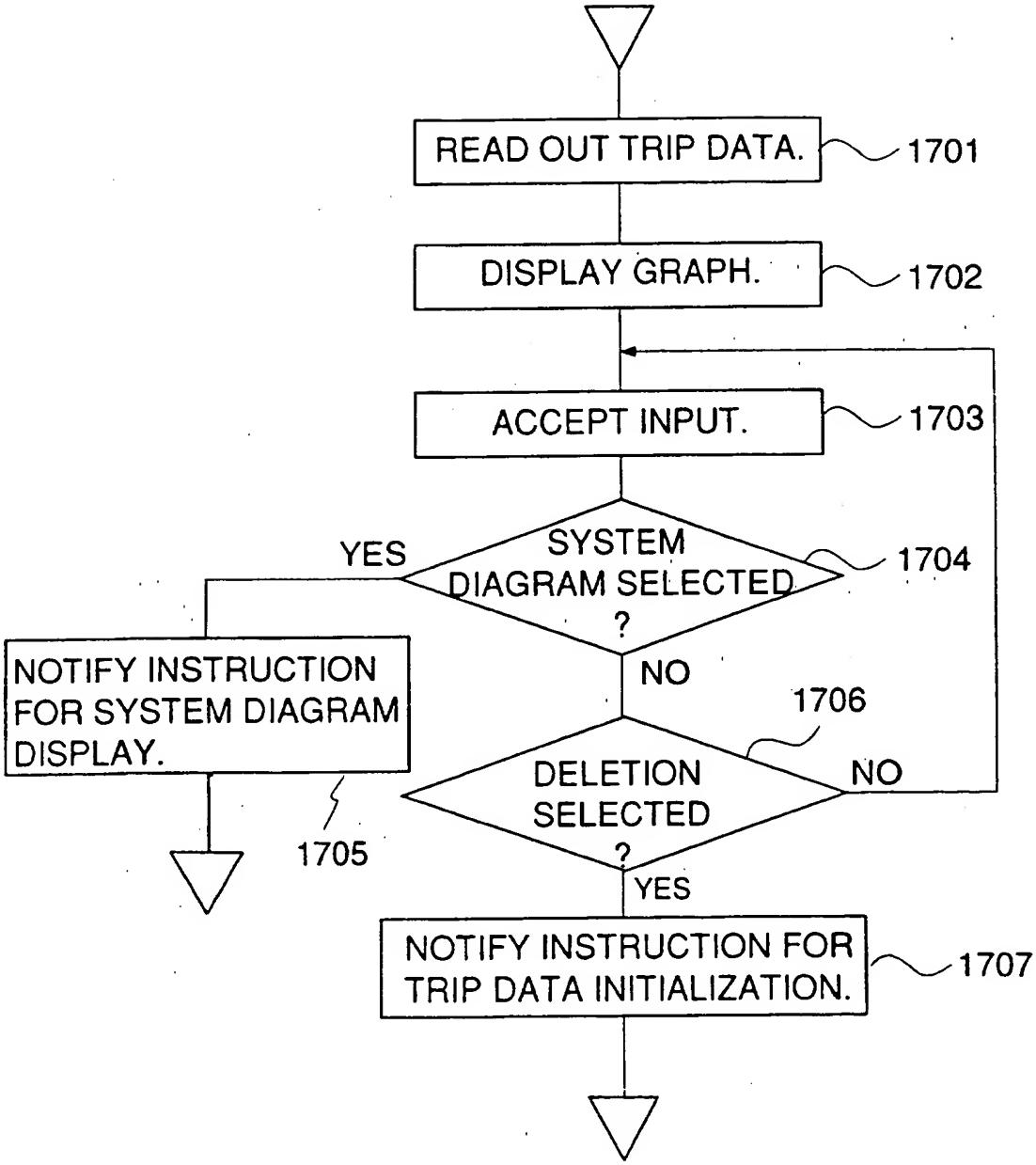

READ OUT TRIP DATA.
1701
DISPLAY GRAPH.
1702
ACCEPT INPUT.
1703
SYSTEM DIAGRAM SELECTED ?
1704
YES
NO
NOTIFY INSTRUCTION FOR SYSTEM DIAGRAM DISPLAY.
1705
1706
DELETION SELECTED ?
NO
YES
NOTIFY INSTRUCTION FOR TRIP DATA INITIALIZATION.
1707

FIG.18

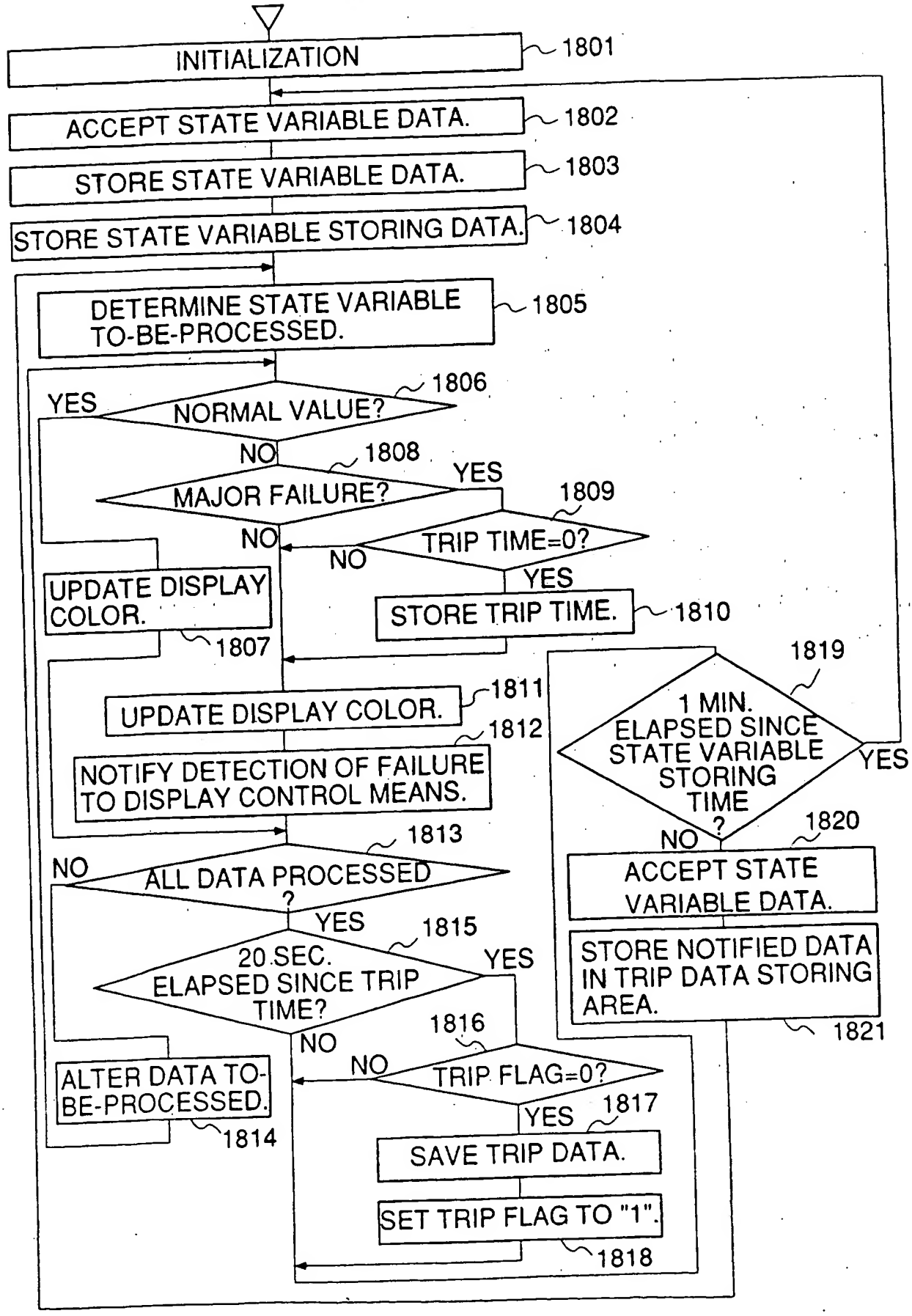
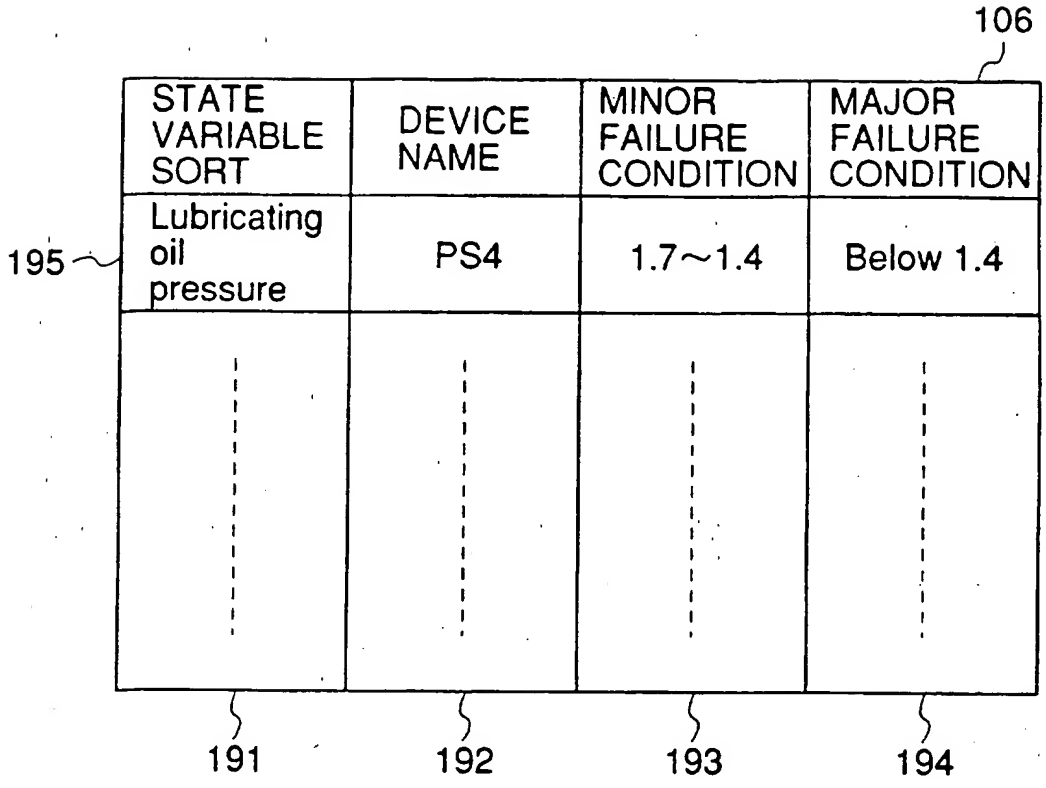

INITIALIZATION
1801
ACCEPT STATE VARIABLE DATA.
1802
STORE STATE VARIABLE DATA.
1803
STORE STATE VARIABLE STORING DATA.
1804
DETERMINE STATE VARIABLE TO-BE-PROCESSED.
1805
NORMAL VALUE?
1806
YES
NO
MAJOR FAILURE?
1808
YES
NO
TRIP TIME=0?
1809
NO
YES
UPDATE DISPLAY COLOR.
1807
STORE TRIP TIME.
1810
UPDATE DISPLAY COLOR.
1811
NOTIFY DETECTION OF FAILURE TO DISPLAY CONTROL MEANS.
1812
ALL DATA PROCESSED ?
1813
NO
YES
20 SEC. ELAPSED SINCE TRIP TIME?
1815
YES
NO
ALTER DATA TO-BE-PROCESSED.
1814
TRIP FLAG=0?
1816
NO
YES
SAVE TRIP DATA.
1817
SET TRIP FLAG TO "1".
1818
1 MIN. ELAPSED SINCE STATE VARIABLE STORING TIME ?
1819
YES
NO
ACCEPT STATE VARIABLE DATA.
1820
STORE NOTIFIED DATA IN TRIP DATA STORING AREA.
1821

FIG.19


106
STATE VARIABLE SORT
DEVICE NAME
MINOR FAILURE CONDITION
MAJOR FAILURE CONDITION
195
Lubricating oil pressure
PS4
1.7~1.4
Below 1.4
191
192
193
194

SUPPORT SYSTEM FOR THE FAILURE ANALYSIS OF A PLANT

The present invention relates to a failure-analysis support system for monitoring a plant and analyzing any failure thereof. More particularly, it relates to a failure-analysis support system which is suited to the state monitoring and failure monitoring of the operation of a gas turbine within an in-situ electric control room.

As illustrated in Fig. 2 of the accompanying drawings, a prior-art gas-turbine control panel 1 for controlling an industrial gas turbine has meters 2 for indicating multifarious state variables, control switches 3 for entering instructions relevant to the control of the operation of the gas turbine, and failure indicating lamps 4. Merely with this construction, however, it is difficult to instantly recognize the state variables of specified components in the complicated systems of the plant.

According to an invention disclosed in the official gazette of Japanese Patent Application Laid-open (*KOKAI*) No. 61-185008 or No. 63-217494, therefore, a plant monitoring system comprises an image display unit, on which

the prestored system diagrams of the plant are displayed to thereby facilitate the recognition of the contents of the systems.

Even with such a technique, however, the failed states of the components are similarly indicated by the failure indicating lamps 4 only. In the case of the occurrence of any failure, accordingly, only the failure indicating lamp 4 corresponding to the failed point is lit up in the control panel 1 for controlling the plant such as industrial gas turbine, and no other information is output to the control panel 1. It is therefore difficult to grasp the cause of the occurrence of the failure in detail. Moreover, a manual needs to be consulted for the purpose of judging how the failure is to be coped with, so that a long time is expended releasing the failed state.

In view of the prior art explained above, the present invention has for its object to provide a failure-analysis support system which permits an operator to readily know the position of a point causing a failure, the situation of the failure and a method of coping with the failure.

In order to accomplish the above object, the present invention provides a support system for the failure analysis of a plant, comprising an image display unit which

includes a display screen, and a control unit which causes the image display unit to display an image on the display screen; the control unit including means for accepting state variable data which indicate states of devices belonging to constituent systems of the plant; monitoring menu display means for displaying a monitoring menu which is a list of the constituent systems of the plant, on the display screen; and failure detection means for judging if any of the devices has failed, on the basis of the state variable data; the monitoring menu display means being furnished with means for highlighting the system to which the device judged as having failed by the failure detection means belongs.

Further, the present invention provides a support system for the failure analysis of a plant, comprising an image display unit which includes a display screen, and a control unit which causes the image display unit to display an image on the display screen; the control unit including means for accepting state variable data which indicate states of devices belonging to constituent systems of the plant; means for accepting selection of any of the constituent systems; system diagram display means for displaying a system diagram of the selected system on the display image; and failure detection means for judging if any of the devices has failed, on the basis of the state variable data; the system diagram containing a display of

the devices which belong to the system indicated by the system diagram; the system diagram display means being furnished with means for highlighting the device which has been judged as having failed by the failure detection means.

In the failure-analysis support system, it is desirable that the control unit further includes monitoring menu display means for displaying a monitoring menu which is a list of the constituent systems, on the display screen; the monitoring menu display means being furnished with means for highlighting the system to which the device judged as having failed by the failure detection means belongs; the system selection acceptance means deciding the selection of any of the constituent systems designated to be displayed by an instruction, when it has accepted the instruction for displaying the constituent system in the monitoring menu.

In addition, the present invention provides a support system for the failure analysis of a plant, comprising an image display unit which includes a display screen, and a control unit which causes the image display unit to display an image on the display screen; the control unit including means for accepting selection of any of the devices which belong to constituent systems of the plant; and text display means for displaying predetermined text information

in accordance with the selected device on the display screen.

Here, the control unit should desirably further include means for accepting state variable data which indicate states of the devices belonging to the constituent systems of the plant; means for accepting selection of any of the constituent systems; system diagram display means for displaying a system diagram of the selected system on the display image; and failure detection means for judging if any of the devices has failed, on the basis of the state variable data; the system diagram containing a display of the devices which belong to the system indicated by the system diagram; the system diagram display means being furnished with means for highlighting the device which has been judged as having failed by the failure detection means; the device selection acceptance means deciding the selection of any of the devices designated to be displayed by an instruction, when it has detected the instruction for displaying the device.

Further, the present invention provides a support system for the failure analysis of a plant, comprising an image display unit which includes a display screen, a control unit which causes the image display unit to display an image on the display screen, and state variable storage means for holding state variable data therein; the control unit including means for accepting the state variable data

which indicate states of devices belonging to constituent systems of the plant; means for saving the accepted state variable data and holding the state variable data, in a way associated with sequence of time, in the state variable storage means; means for accepting selection of a type of the state variable data; and trend graph display means for reading the state variable data of the selected type out of the state variable storage means and then displaying the read state variable data on the display screen.

Here, it is desirable that the trend graph display means displays the state variable data as a graph. Besides, the control unit should desirably further include means for accepting selection of any of the constituent systems; system diagram display means for displaying a system diagram of the selected system on the display image; and failure detection means for judging if any of the devices has failed, on the basis of the state variable data; the system diagram containing a display of the devices which belong to the system indicated by the system diagram, as well as the state variable data of the devices; the system diagram display means being furnished with means for highlighting the device which has been judged as having failed by the failure detection means; the state-variable-data-type selection acceptance means deciding the selection of any of the state variable data types designated to be

displayed by an instruction, when it has detected the instruction for displaying the state variable data type.

Moreover, the present invention provides a support system for the failure analysis of a plant, comprising an image display unit which includes a display screen, a control unit which causes the image display unit to display an image on the display screen, and trip data save means for holding state variable data therein; the control unit including means for accepting an external instruction; failure detection means for judging if any major failure has occurred, on the basis of the state variable data; means for saving the state variable data accepted thereby during a predetermined time period before and after a time point at which the major failure has been detected, and holding the state variable data, in a way associated with sequence of time, in the trip data save means; and trend graph display means for reading the state variable data out of the trip data save means and then displaying the read state variable data on the display screen, in compliance with the instruction.

The state variable data may be held in said trip save means in such a way that the order in which the state variable data are generated can be known.

Here, it is desirable that the trend graph display means displays the state variable data as a graph. Besides, the failure-analysis support system should

desirably further comprise an external storage; the trip data save means being located in the external storage.

Further, the present invention provides a method wherein a plant having at least one constituent system which includes at least one device is managed by a failure-analysis support system comprising an image display unit which includes a display screen, and a control unit which causes the image display unit to display an image on the display screen; the control unit including means for accepting state variable data which indicate states of the devices; monitoring menu display means for displaying a monitoring menu which is a list of the constituent systems, on the display screen; and failure detection means for judging if any of the devices has failed, on the basis of the state variable data; the monitoring menu display means being furnished with means for highlighting the system to which the device judged as having failed by the failure detection means belongs; information of a failed point being obtained by referring to the display screen.

In operation, the monitoring menu display means in the present invention displays a system name in a background color corresponding to the degree of failure, on a monitoring menu image. It is therefore possible to readily know the constituent system undergoing the failure and the degree of the failure. Besides, in the present invention, a system diagram display image which contains the system

diagram of the constituent system displayed in the system name display area of the monitoring menu is displayed in response to a system operator touching this system name display area. It is therefore possible to readily know the device undergoing the failure and the degree of the failure, owing to the background color of a device name display.

Moreover, a device information supplying image which contains the explanation of the device displayed in the device name display area of the system diagram display image and a method of coping with the failure, is displayed in response to the the system operator touching this device name display area. Besides, a trend graph which indicates the time variation of the value of a state variable displayed in the state variable display area of the system diagram display image and the time variations of the values of state variables relevant to the first-mentioned state variable, is displayed in response to the system operator touching this state variable display area. In this manner, according to the present invention, the various items of information necessary for the judgements on how to cope with the failure are immediately supplied. Therefore, the system operator can quickly grasp the situation of the failure and can readily select the method of coping with the failure.

Further, according to the present invention, in a case where a trip has occurred in the plant, the state variable data for a predetermined time period within which the time point of the detection of the occurrence lies, are saved in the external storage, and the saved data can be displayed as the graph. It is therefore possible to support analysis of the cause of the failure which is carried out after the trip.

Incidentally, the individual means included in the control unit of the failure-analysis support system according to the present invention may be either ones implemented in such a way that a central processing unit executes instructions held in the main storage of an information processing system beforehand, that is, ones implemented by software, or ones implemented by hardware such as dedicated circuits. Besides, in the case where the means are implemented by software, a storage medium in which the software is previously held may well be prepared so as to load, at least, some of the constituent instructions of the software from the storage medium into the main storage, and to execute the loaded instructions.

Furthermore, the present invention provides the method for the failure analysis of the plant and the management thereof, by the use of the support system for the failure analysis of the plant as described above. With the failure-analysis support system according to the

present invention, the information items on the situation of the failed point and the method of coping with the failure can be readily known, so that the manager of the plant can quickly cope with the failure by utilizing these information items.

In the drawings:

Fig. 1 is a block diagram showing the system configuration of a gas-turbine control panel in an embodiment;

Fig. 2 is an exterior view showing a gas-turbine control panel in the prior art;

Fig. 3 is an explanatory view showing the transition of system diagram display images in an embodiment;

Fig. 4 is an explanatory view showing the transition of monitoring menu images in an embodiment;

Fig. 5 is an explanatory view showing a device information supplying image in an embodiment;

Fig. 6 is an explanatory view showing a trend graph image in an embodiment;

Fig. 7 is an explanatory view showing the transition of display images in an embodiment;

Fig. 8 is an explanatory view showing a trip data image in an embodiment;

Fig. 9 is a block diagram showing the hardware architecture of a failure-analysis support system in an embodiment;

Fig. 10 is a block diagram showing the functional modules of a failure-analysis support system in an embodiment;

Fig. 11 is a schematic diagram showing the data structure of system diagram storage means;

Fig. 12 is a flow chart showing the processing of display control means;

Fig. 13 is a flow chart showing the processing of monitoring menu display means;

Fig. 14 is a flow chart showing the processing of system diagram display means;

Fig. 15 is a flow chart showing the processing of text display means;

Fig. 16 is a flow chart showing the processing of trend graph display means for displaying a trend graph image;

Fig. 17 is a flow chart showing the processing of the trend graph display means for displaying a trip data image;

Fig. 18 is a flow chart showing the processing of failure detection means; and

Fig. 19 is a schematic diagram showing the data structure of criteria storage means.

Now, embodiments of the present invention will be described with reference to the accompanying drawings.

A. Configuration of Failure-analysis Support System

As shown in Fig. 1, a failure-analysis support system 20 in this embodiment is installed in a gas-turbine control panel 25 which controls a plant 21 including a gas turbine for industrial use. The gas-turbine control panel 25, which is connected with the plant 21 by signal lines 22, has plant control means 23 and the failure-analysis support system 20. The plant control means 23 accepts the output signals of the various devices of the plant 21 through the signal lines 22, and it executes calculations and decisions on the basis of the accepted signals to create control commands for the individual devices of the plant 21. The created control commands are notified to the devices through the signal lines 22.

As seen from Fig. 1, the failure-analysis support system 20 in this embodiment comprises a control unit 5 for creating information to-be-output, input/output (I/O) means 6, and a memory unit 7 for holding information therein. The control unit 5 is connected to the plant control means 23 through a signal line 24. It accepts the notifications of the state variable data of the various devices from the plant control means 23. Besides, it notifies information

such as the state variable data to the memory unit 7 and notifies image information to-be-displayed to the I/O means 6. By the way, the hardware architecture of the failure-analysis support system 20 in this embodiment is as shown in Fig. 9 and is configured of a main storage 91, a CPU (Central Processing Unit) 92, an external storage 93 and the I/O means 6.

(1) Input/Output Means

The input/output means 6 accepts the inputs of instructions issued externally of the support system 20 and notifies the accepted inputs to the control unit 5, while it displays an image in accordance with the image information notified from the control unit 5. Herein, the I/O means 6 is furnished with an image display unit 61 which is a graphic panel for displaying an image. Although the image display unit 61 in this embodiment is a CRT (Cathode Ray Tube), any other means such as a liquid-crystal display unit may well be employed. In this embodiment, the output screen of the image display unit 61 has a touch sensor and serves also as input means. Alternatively, a keyboard and/or a mouse may well be disposed as input means, by way of example.

(2) Memory Unit

The memory unit 7 is a storage area which is reserved in the external storage 93. As shown in Fig. 10, it includes as functional blocks, system diagram storage means

107, text storage means 108, state variable storage means 109, trip data save means 110 and criteria storage means 106. Data are registered in the system diagram storage means 107, text storage means 108 and criteria storage means 106 beforehand on the basis of the design information etc. of the plant 21.

As shown in Fig. 11, the system diagram storage means 107 possesses a system table 111 which is the list of systems constituting the plant 21, and device tables 112 in each of which information items for creating a system diagram are held. Regarding each of the constituent systems of the plant 21, the system table 111 contains a system name storage area 1111 which holds a system name therein, a system name display color storage area 1112 which holds therein the display color of a rectangular area for displaying the corresponding system (the background color of the system name to be displayed), and a device table address storage area 1113 which holds the address of the device table 112 therein.

Regarding each of the devices which belong to the system expressed by the device table 112, this table 112 contains a device information storage area 1121 which holds a device name therein, a display position storage area 1122 which holds therein the display position of the corresponding device on the system diagram, a display color storage area 1123 which holds therein the display color of

a rectangular area for displaying the corresponding device (the background color of the device name to be displayed), a state variable storage area 1124 which holds the state variable data of the corresponding device therein, and a graphic information storage area 1125 which holds therein graphic information items such as the size of the rectangular area for displaying the corresponding device and the relation of connection of this rectangular area with the rectangular area of any other device. Incidentally, the data of a state variable which is measured by the pertinent device is held in the state variable storage area 1124, but data indicative of the absence of the state variable (here in this embodiment, "Null") is held for the device which measures no state variable. In Fig. 11, the information items held in the graphic information storage area 1125 are omitted from illustration.

Regarding each of the devices, text information items on the pertinent device (information items such as the name and purpose of the device and a method of coping with the failure of the device) are previously registered in the text storage means 108. By the way, in this embodiment, one sort of text is registered for every device, but a plurality of sorts of texts may well be registered in correspondence with the respective states (normal state, minor failure and major failure) of the device.

As to each of the sorts of state variable, the state variable storage means 109 contains state variable storage areas (not shown) for a predetermined time period, in each of which the state variable data of a predetermined unit time (in this embodiment, 1 minute) are held. The state variable storage areas are connected by the links of the individual sorts of state variable, and the links are in the sequence in which the information items have been recorded. By the way, in this embodiment, the areas corresponding to 3 hours (state variable storage areas in the number of 180 for each of the devices) are reserved. In a case where the operating time of the support system has exceeded 3 hours, the state variable data are stored in the storage area for holding the oldest information therein.

Incidentally, the sorts of the state variable are stipulated beforehand. In this embodiment, in the case of a lubricating oil system by way of example, the five sorts of state variable, which consist of the temperature of the bearing of the gas turbine, the temperature of lubricating oil, the pressure of the lubricating oil, the temperature of the bearing of a dynamo, and the temperature of a lubricating oil tank, are measured, monitored and stored.

As to each of the sorts of state variable, the trip data save means 110 contains state variable storage areas (not shown) for a predetermined time period, in each of

which the state variable data of a predetermined unit time (in this embodiment, 1 second) are held. The state variable storage areas are connected by the links of the individual sorts of the state variable, and the links are in the sequence in which the information items have been recorded. In this embodiment, the areas corresponding to 60 seconds (state variable storage areas in the number of 60 for each of the devices) are reserved.

The criteria storage means 106 is a storage area in which, for each of the devices, a predetermined criterion for judging if the pertinent device undergoes a failure is held for each of the minor failure and the major failure. Here, the criterion conforms to an if-then rule which is composed of an if-part, "if the state variable data of a specified state variable sort has a certain value", and a then-part, "then, the pertinent device undergoes a failure of a specified degree (the major failure or the minor failure)". As shown in Fig. 19, therefore, the criteria storage means 106 possesses a line for every rule, the line containing a state variable sort storage area 191 in which the state variable sort to be judged is held, a device name storage area 192 in which the name of the device described in the then-part is held, a minor failure condition storage area 193 in which the condition of the minor failure is held, and a major failure condition storage area 194 in which the condition of the major failure is held.

In this embodiment, by way of example, if the lubricating oil pressure is 1.7 - 1.4 kg/cm^2, then a pressure switch "PS4" is judged to undergo the minor failure, and if the lubricating oil pressure is below 1.4 kg/cm^2, then the pressure switch "PS4" is judged to undergo the major failure. As seen from Fig. 19, therefore, the criteria storage means 106 possesses the line 195 at which "Lubricating oil pressure" is held in the state variable sort storage area 191, "PS4" in the device name storage area 192, "1.7 - 1.4" in the minor failure condition storage area 193, and "Below 1.4" in the major failure condition storage area 194.

(3) Control Unit

As shown in Fig. 10, the control unit 5 includes as functional blocks, display control means 100, monitoring menu display means 101, system diagram display means 102, failure detection means 103, text display means 105, trend graph display means 104, display image storage means 97, system name storage means 98 and trip data storage means 99. Incidentally, the means 100 - 105 mentioned above are implemented in such a way that the CPU 92 executes instructions held in the main storage 91 beforehand. These means 100 - 105, however, may well be implemented by hardware such as dedicated circuits. Besides, the storage means 97 - 99 are storage areas reserved in the main storage 91.

The display image storage means 97 is a storage area for holding one image name therein, while the system name storage means 98 is a storage area for holding one system name therein.

As to each of the sorts of state variable, the trip data storage means 99 contains state variable storage areas for a predetermined time period, in each of which the state variable data of a predetermined unit time (in this embodiment, 1 second) are held. The state variable storage areas are connected by the links of the individual sorts of state variable, and the links are in the sequence in which the information items have been recorded. By the way, in this embodiment, the areas corresponding to 60 seconds (state variable storage areas in the number of 60 for each of the devices) are reserved. In a case where the operating time of the support system has exceeded 60 seconds, the state variable data are stored in the storage area for holding the oldest information therein.

The display control means 100 includes means for a control for presenting an image display, and means for a control for altering a display color. The means for the control for presenting the image display causes any of the monitoring menu display means 101, system diagram display means 102, text display means 105 and trend graph display means 104 to display an image in compliance with an instruction accepted through the I/O means 6. On condition

that the image currently displayed on the display screen is the monitoring menu or the system diagram, the control means for altering the display color causes the monitoring menu display means 101 or system diagram display means 102 to alter the display color of the device judged as undergoing the failure (the color of the rectangular area in which the device name is displayed), to the color corresponding to the degree of the failure, on the basis of the failure data notified by the failure detection means 103 (the failure data consist of the device name of the device judged as undergoing the failure, and information indicative of the degree of the failure, namely, either the minor failure or the major failure).

The monitoring menu display means 101 delivers the list of the constituent systems of the plant 21 as shown at (a) in Fig. 4, to the display screen of the image display unit 61 on the basis of the information held in the system table 111.

The system diagram display means 102 delivers the system diagram of the constituent system designated by an instruction as shown at (a) in Fig. 3, to the display screen of the image display unit 61 on the basis of the information held in the device table 112.

The text display means 105 delivers the explanatory notes of the device designated by an instruction as shown in Fig. 5, to the display screen of the image display unit

61 on the basis of the information held in the text storage means 108.

The trend graph display means 104 includes first means and second means. In the case of an instruction for designating the output of a trend graph in the normal state of the plant 21, the first means delivers a graph indicating the transitions of the state variable data of the individual state variable sorts as shown in Fig. 6, to the display screen of the image display unit 61 on the basis of the information held in the state variable storage means 109. On the other hand, in the case of an instruction for designating the output of a trend graph in the event of a trip (the occurrence of a major failure, during which the plant 21 is stopped in this embodiment), the second means delivers a graph indicating the transitions of the state variable data of the individual state variable sorts as shown in Fig. 8, to the display screen of the image display unit 61 on the basis of the information held in the trip data save means 110.

The failure detection means 103 includes first, second and third means. The first means stores the state variable data notified through the signal line 24 by the plant control means 23, in the system diagram storage means 107, trip data storage means 99 and state variable storage means 109. The second means judges if the state variable data are normal values, on the basis of the criteria held in the

criteria storage means 106, and it notifies any abnormality to the display control means 100. When the occurrence of the trip has been detected, the third means copies the contents of the trip data storage means 99 into the trip data save means 110 after a predetermined time period (after 20 seconds in this embodiment).

B. Transition of Display Images

Next, the images which are displayed on the display screen of the image display unit 61 in this embodiment will be described along with the transitions thereof. The transitions of the display images in this embodiment are illustrated in Fig. 7.

(1) Monitoring Menu Image

In the initial state of the failure-analysis support system 20 immediately after the start thereof, a monitoring menu image 70a is displayed on the display screen 70 as shown at (a) in Fig. 7. The monitoring menu image 70a is exemplified in Fig. 4. As shown at (a) in Fig. 4, the monitoring menu image 70a contains a rectangular area 14 for displaying a system name, for each of the constituent systems of the plant 21. Since, in this embodiment, the plant 21 is constituted by 9 systems, the image 70a contains the system name display areas 14 in the number of 9. Further, the monitoring menu image 70a contains a notes area 10 for displaying predetermined information. The notes display area 10 displays the information important

for the control of the plant 21, and it is contained in all images 70a - 70e in common.

By the way, when any failure has been detected by the failure detection means 103, the display color of the system name display area 14 of the constituent system in which the failure has been detected is altered as shown at (b) in Fig. 4. In this embodiment, the display color of the system name is black. Besides, the display color of the display area 14 (the color of the background of the system name) is white when no failure is detected, it is yellow when a minor failure has been detected, and it is red when a major failure has been detected. According to this embodiment, therefore, the operator of the support system 20 can immediately judge the constituent system undergoing the failure and the level of this failure. Incidentally, exemplified at (b) in Fig. 4 is a case where the failure has been detected in the "lubricating oil system".

When the system operator touching the system name display area 14 has been detected by the I/O means 6, the system diagram display image 70b which contains the system diagram of the system displayed in the area 14 is responsively displayed as shown at (b) in Fig. 7.

(2) System Diagram Display Image

The system diagram display image 70b is illustrated in Fig. 3. It contains a system diagram display area 9, a

selection area 12 and the notes display area 10. The system diagram of the selected constituent system is displayed in the system diagram display area 9. This system diagram is composed of device display areas 11 which display the devices belonging to the constituent system, lines 31 which indicate the relations of the devices, and data display areas 17 which display the state variable data. Incidentally, the display example shown at (a) in Fig. 3 corresponds to a case where the lubricating oil system has been selected. The state variable display area 17 is associated with the device display area 11 of the device by which the state variable to be displayed in the former area 17 is measured.

In this embodiment, a pressure switch "PS4" and a pressure transducer "PT6" are included in the lubricating oil system, so that the rectangular area 11a for the device "PS4" and the rectangular area 11b for the device "PT6" are displayed within the system diagram displayed in the system diagram display area 9. The pressure switch "PS4" detects the presence or absence of the lubricating oil pressure in the lubricating oil system. On the other hand, the pressure transducer "PT6" converts the lubricating oil pressure in the lubricating oil system. Since the pressure transducer "PT6" has the state variable indicating the state of this device, a pressure value of 270 kPa being the

data of the state variable is displayed in the state variable display area 17a near the area 11b.

By the way, when any failure has been detected by the failure detection means 103, the display color of the area 11 displaying the name of the device whose failure has been detected is altered as shown at (b) in Fig. 3. The display colors of the device name and the device display area 11 are the same as in the foregoing case of the system name and the system display area 14. According to this embodiment, therefore, the operator of the support system 20 can immediately judge the device undergoing the failure and the level of this failure. Incidentally, exemplified at (b) in Fig. 3 is a case where the device "PS4" has failed.

An instruction for displaying the monitoring menu image 70a is defined in the selection area 12a beforehand. When the system operator touching the selection area 12a has been detected by the I/O means 6, the monitoring menu image 70a explained above is responsively displayed as shown at (a) in Fig. 7.

When the touching of the device display area 11 has been detected by the I/O means 6, the device information supplying image 70c indicating the text which has been previously registered in the text storage means 108 in correspondence with the device defined in this area 11 is responsively displayed as shown at (c) in Fig. 7.

When the touching of the state variable display area 17 has been detected by the I/O means 6, the trend graph image 70d containing the display of the graph which indicates the time variations of the state variable data is responsively displayed as shown at (d) in Fig. 7.

An instruction for displaying the trip data image 70e is defined in the selection area 12b beforehand. When the touching of the selection area 12b has been detected by the I/O means 6, the trip data image 70e is responsively displayed as shown at (e) in Fig. 7.

(3) Device Information Supplying Image

The device information supplying image 70c is illustrated in Fig. 5. It contains a text display area 15 for displaying the text of device information, a notes display area 10 and a selection area 12e. The text display area 15 displays the text information items (such as the name and purpose of the device, and the method of coping with the failure of the device) held in the text storage means 108, in correspondence with the device defined in the device display area 11 which has been touched in the system diagram display image 70b.

An instruction for displaying the system diagram display image 70b is defined in the selection area 12e beforehand. When the system operator touching the selection area 12e has been detected by the I/O means 6, the system diagram display image 70b displayed immediately

before is responsively re-displayed as shown at (b) in Fig. 7.

Incidentally, Fig. 5 exemplifies a case where the touching of the display area 11a of the device "PS4" has been detected in the system diagram display image 70b. The text which is displayed in the case of the selection of the device "PS4" contains the fact that the device "PS4" is the lubricating oil pressure switch, the fact that the purpose of the device is to detect the presence or absence of the pressure, the fact that the operating pressure of the switch is at least 140 kPa, and the method by which the failure of the switch is coped with.

In this manner, the explanatory information and the failure countermeasures for each device can be displayed as required. According to this embodiment, therefore, how the failure that has occurred is to be dealt with can be immediately taught to the system operator.

(4) Trend Graph Image

The trend graph image 70d is illustrated in Fig. 6. It contains a trend graph display area 18 for displaying a graph expressive of the time variations of the state variable data, a notes display area 10 and a selection area 12e. As in the foregoing case, when the system operator touching the selection area 12e has been detected, the system diagram display image 70b displayed immediately

before is responsively re-displayed as shown at (b) in Fig. 7.

The combination of the state variable sorts to be displayed in the trend graph display area 18 is stipulated for every device beforehand. The state variable data to be displayed in the trend graph image 70d are the data of the state variables of the state variable sorts in the combination previously stipulated in correspondence with the device defined in that device display area 11 associated with the state variable display area 17 for which touching has been detected in the system diagram display image 70b. Besides, the graph to be displayed in the trend graph display area 18 is created on the basis of the state variable data held in the state variable storage means 109.

Fig. 6 exemplifies a case where the touching of the display area 17a of the device "PT6" has been detected in the system diagram display image 70b. The state variable sorts stipulated in correspondence with the device "PT6" are the temperature of a bearing, the temperature of lubricating oil and the pressure of the lubricating oil. Therefore, when it has been detected that the area 17a has been touched, the graph indicating the time variations of the bearing temperature, the lubricating oil temperature and the lubricating oil pressure which are stipulated in correspondence with the device "PT6" of the device display

area 11b associated with the area 17a is displayed in the graph display area 18 of the trend graph image 70d.

In this embodiment, the trend graph is immediately displayed as required as explained above. Thus, the system operator can be assisted in judging how the failure proceeded with the lapse of time and if the failed state is being currently reached.

(5) Trip Data Image

The trip data image 70e is illustrated in Fig. 8. It contains a trip data display area 19 for displaying a graph expressive of the time variations of state variable data before and after a trip, a notes display area 10, a system diagram selection area 12e and a deletion selection area 12f. As in the foregoing case, when it has been detected that the system operator has touched the selection area 12e, the system diagram display image 70b is re-displayed.

The graph to be displayed in the trip data display area 19 is created on the basis of the state variable data held in the trip data save means 110. Which of the state variable sorts are to be used for creating the graph, among the state variable data held in the trip data save means 110, are stipulated beforehand.

An instruction for initializing the trip data is defined in the deletion selection area 12f beforehand. In this embodiment, once the trip data have been saved in the trip data save means 110, no data is stored in this means

110 even upon detection of the occurrence of a further trip, without the initialization of the trip data. This is intended to prevent the saved data from being destroyed by overwriting. When it has been detected by the I/O means 6 the system operator has touched the selection area 12f, the contents of the trip data save means 110 are responsively initialized, thereby permitting data to be saved upon the detection of the occurrence of the next trip.

In this embodiment, the trend graph is immediately displayed as required as explained above. Thus, the system operator can be assisted in analyzing the cause of the failure.

C. Processing of Failure Detection Means

The flow of the processing of the failure detection means 103 is illustrated in Fig. 18. The failure detection means 103 is started with the start of the gas-turbine control panel 25. In this embodiment, state variable data are notified from the plant control means 23 to the failure detection means 103 through the signal line 24 at time intervals of 1 second.

When started, the failure detection means 103 first executes initialization (step 1801). More specifically, a state-variable-storing-time storage area (not shown), a trip time storage area (not shown) and a trip flag storage area (not shown) are reserved as temporary storage areas in the main storage 91, and "0's" are stored as initial values

in the state-variable-storing-time storage area, the trip time storage area, the trip flag storage area, the state variable storage area 1124 of the system diagram storage means 107, the state variable storage means 109 and the trip data storage means 99.

Subsequently, the failure detection means 103 accepts the notification of one set of state variable data from the plant control means 23 (step 1802). The notified state variable data are stored in the state variable storage area 1124 of the system diagram storage means 107, the state variable storage means 109 and the trip data storage means 99 in accordance with the state variable sorts of the notified data (step 1803). The current time is stored in the state-variable-storing-time storage area (step 1804).

Further, the failure detection means 103 determines any of the accepted set of state variable data (in this embodiment, the data notified earliest), as an object to-be-processed (step 1805), and it executes the succeeding steps 1806 - 1814.

At the step 1806, the failure detection means 103 judges if the notified state variable data has a normal value, on the basis of criteria held in the criteria storage means 106. More specifically, the criteria storage means 106 is searched for all the lines 195 at which the sort of the state variable data to-be-processed is held in the state variable sort storage areas 191. In a case where

the notified data meets neither of the conditions held in the minor failure condition storage areas 193 and major failure condition storage areas 194 of all the lines 195 searched for, it is judged as having the normal value, and in a case where it meets either of the conditions, it is judged as having an abnormal value.

Subject to the normality, the failure detection means 103 updates display color information held in the system diagram storage means 107, to information which indicates "white" signifying the normality (step 1807). This step 1807 is followed by the step 1813.

At the step 1807, the failure detection means 103 searches the system diagram storage means 107 for all the device tables 112 containing those lines of the system table 111 at which the device names of the devices detected normal at the step 1806 (the device names held in the device name storage areas 192 of the lines 195 detected in the criteria storage means 106) are held in the device name storage areas 1121. Subsequently, the failure detection means 103 stores the information indicative of "white" in the display color storage areas 1123 of all those lines of the device tables 112 searched for at which the device names of the devices detected normal are held in the device name storage areas 1121. Further, for all the device tables 112 in which the contents of the areas 1123 have been altered, the failure detection means 103 scans the

areas 1123 of all the lines of the updated tables 112. On condition that no area 1123 holds information indicative of any color other than "white", the system table 111 is searched for the lines at which the addresses of the device tables 112 are held in the device table address storage areas 1113, and the information indicative of "white" is stored in the system-name display color storage areas 1112 of the lines searched for.

In the case where the abnormality has been detected at the step 1806, the processing proceeds as described below. Subject to the minor failure (step 1808), the failure detection means 103 advances the processing to the step 1811 directly. In contrast, subject to the major failure (step 1808), the failure detection means 103 judges if the value held in the trip time storage area is "0" (step 1809). When the held value is not "0", a trip time is already set. Therefore, the failure detection means 103 advances the processing to the step 1811 directly. On the other hand, when the held value is "0", the trip time is not set yet. Therefore, the failure detection means 103 stores the current time in the trip time storage area (step 1810) and thereafter advances the processing to the step 1811.

At the step 1811, the failure detection means 103 updates the display color information held in the system diagram storage means 107, to the information corresponding

to the detected failure. More specifically, the failure detection means 103 searches the system diagram storage means 107 for all the device tables 112 containing those lines of the system table 111 at which the device names of the devices detected as having failed are held in the device name storage areas 1121. Subsequently, the failure detection means 103 stores the display color information corresponding to the levels of the detected failures (the information indicative of "red" for the major failure, and the information indicative of "yellow" for the minor failure), in the display color storage areas 1123 of all those lines of the device tables 112 searched for at which the device names of the devices detected as having failed are held in the device name storage areas 1121. Further, for all the device tables 112 searched for, the failure detection means 103 searches the system table 111 for the lines at which the addresses of the device tables 112 are held in the device-table address storage areas 1113, and it stores the information corresponding to the levels of the detected failures (the information indicative of "red" for a major failure, and the information indicative of "yellow" for a minor failure), in the system-name display color storage areas 1112 of the lines searched for.

Incidentally, the level of the failure of each of the constituent systems on this occasion is decided by checking all the display color storage areas 1123 contained in the

device table 112 of the pertinent constituent system. More specifically, in a case where any of the areas 1123 holds the information indicative of "red", the pertinent constituent system is determined as undergoing a major failure. Also, in a case where none of the areas 1123 holds the information indicative of "red" and where any of the areas 1123 holds the information indicative of "yellow", the pertinent constituent system is determined as undergoing a minor failure. Besides, in a case where all the areas 1123 hold the information indicative of "white", the pertinent constituent system is determined as being normal.

Subsequently, the failure detection means 103 notifies the detection of the failure to the display control means 100 (step 1812). This step 1812 is followed by the step 1813.

At the step 1813, the failure detection means 103 judges if any of the state variable data is not processed yet. In the presence of the unprocessed data (step 1813), the means 103 determines any of the unprocessed data as an object to-be-processed (step 1814), and it returns the processing to the step 1806.

In the absence of the unprocessed data, the failure detection means 103 checks if a time period of 20 seconds has elapsed since the time held in the trip time storage area (step 1815). In a case where the time period of 20

seconds has elapsed, the failure detection means 103 checks the value held in the trip flag storage area (step 1816). In a case where the time period of 20 seconds has not elapsed since the trip time or where the trip flag is not "0" in spite of the elapse, the failure detection means 103 advances the processing to a step 1819 without saving the trip data.

On condition that the time period of 20 seconds has elapsed since the trip time and that the trip flag is "0", the failure detection means 103 copies the held data of the trip data storage means 99 into the trip data storage means 110 of the external storage 93 (step 1817) and stores "1" in the trip flag storage area (step 1818).

Subsequently, the failure detection means 103 checks if a time period of 1 minute has elapsed since the time held in the state-variable-storing-time storage area (step 1819). In a case where the time period has elapsed, the failure detection means 103 returns the processing to the step 1802. On the other hand, in a case where the time period has not elapsed, the means 103 accepts the notification of one set of state variable data from the plant control means 23 (step 1820) and stores the notified state variable data in the storage areas of the trip data storage means 99 corresponding to the state variable sorts of these data (step 1821). Thereafter, the processing is returned to the step 1805.

D. Processing of Display Control Means and Individual Display Means

(1) Initialization

The flow of the processing of the display control means 100 is illustrated in Fig. 12. The display control means 100 is started with the start of the gas-turbine control panel 25. After storing the identification information of a monitoring menu image 70a in the display image storage means 97, the display control means 100 commands the monitoring menu display means 101 to display the monitoring menu image 70a as an initial image on the display screen 70 of the image display unit 61 (step 1201). Subsequently, the means 100 waits for an input from any of the individual display means 101, 102, 104 and 105 and the failure detection means 103 (step 1202).

The monitoring menu display means 101 having received the command displays the monitoring menu image 70a as shown in Fig. 13 (step 1301). On this occasion, the monitoring menu display means 101 creates and displays the list of system names by iterating the following procedure: For each of the lines of the system table 111, the system name display area 14 of an object to-be-processed is filled in with the display color held in the system-name display color storage area 1112 of the pertinent line, whereupon the system name held in the system name storage area 1111 of the same line is displayed in the area 14.

Subsequently, the monitoring menu display means 101 accepts the input of the system name (step 1302). More specifically, the display screen 70 of the image display unit 61 is furnished with touch sensors. Upon detecting that the system operator touches any system name display area 14, the I/O means 6 decides that the system name displayed in the area 14 has been input, and it notifies the system name to the monitoring menu display means 101.

The monitoring menu display means 101 having received the notification of the system name stores the notified system name in the system name storage means 98 (step 1303), and it notifies the fact that an instruction for displaying the system diagram has been given (step 1304), to the display control means 100. Then, the processing is ended.

(2) Image Display Processing

When the display control means 100 waiting at the step 1202 in Fig. 12 is supplied with any input, it advances the processing to a step 1204, a step 1214 or a step 1218 in accordance with the content of the input (step 1203). Here, image display processing (steps 1204 - 1213) will be first explained for cases where the input is not from the failure detection means 103.

a. Display of Monitoring Menu Image

Upon accepting the input which is not from the failure detection means 103, the display control means 100 checks

if the content of the instruction designates the display of the monitoring menu image (step 1204). Subject to the display of the monitoring menu image, the means 100 stores the ID information of the monitoring menu image 70a in the display image storage means 97 and thereafter commands the monitoring menu display means 101 to display the monitoring menu image 70a on the display screen 70 (step 1205). Subsequently, the processing is returned to the step 1202. The commanded monitoring menu display means 101 displays the monitoring menu image 70a owing to the steps 1301 - 1304 in Fig. 13 as described before.

b. Display of System Diagram Display Image

If the content of the instruction designates the display of the system diagram (step 1206), the display control means 100 stores the ID information of the system diagram display image 70b in the display image storage means 97 and thereafter commands the system diagram display means 102 to display the system diagram display image 70b on the display screen 70 (step 1207). Subsequently, the processing is returned to the step 1202.

As shown in Fig. 14, the commanded system diagram display means 102 reads out the system name held in the system name storage means 98 (step 1401), and it searches the system table 111 for the address held in the device table address storage area 1113, at the line at which the

read-out system name is held in the system name storage area 1111 (step 1402).

Subsequently, the system diagram display means 102 displays the system diagram display image 70b on the display screen 70 on the basis of the information items which are held in the device table 112 of the address searched for (step 1403). On this occasion, for each of the lines of the device table 112, the system diagram display means 102 creates the rectangular area 11 at that position of the screen 70 which is indicated by the positional information held in the display position storage area 1122 of the pertinent line, and in the display color which is held in the display color storage area 1123. The device held in the device name storage area 1121 at the same line is displayed in the created area 11. Further, unless the value held in the state variable storage area 1124 is "null", the means 102 reserves the state variable display area 17 near the area 11, and it displays the state variable data held in the area 1124, in the reserved area 17.

When the image 70b is displayed, the system diagram display means 102 accepts through the input means 6, the input of any of instructions which are previously defined in the device display area 11, state variable display area 17, monitoring menu selection area 12a and trip data

selection area 12b, and which are input by touching these areas (step 1404).

In a case where the input instruction designates the display of the monitoring menu (the input based on the touching the monitoring menu selection area 12a) (step 1405), the system diagram display means 102 notifies the instruction for displaying the monitoring menu image 70a, to the display control means 100 (step 1406), and it ends the processing.

In a case where the input instruction designates the supply of the device information (the input based on the touch with the device display area 11) (step 1407), the system diagram display means 102 notifies the instruction for displaying the device information supplying image 70c, to the display control means 100 (step 1408), and it ends the processing.

In a case where the input instruction designates the display of the trend graph (the input based on the touch with the state variable display area 17) (step 1409), the system diagram display means 102 notifies the instruction for displaying the trend graph image 70d, to the display control means 100 (step 1410), and it ends the processing.

In a case where the input instruction designates the display of the trip data (the input based on the touch with the trip data selection area 12b) (step 1411), the system diagram display means 102 notifies the instruction for

displaying the trip data image 70e, to the display control means 100 (step 1412), and it ends the processing. At this stage, in a case where the input instruction does not designate the display of the trip data (step 1411), the input is an error. Therefore, the system diagram display means 102 returns the processing to the step 1404 so as to accept an input again.

c. Display of Device Information Supplying Image

If the content of the instruction designates the display of the device information supplying image (step 1208 in Fig. 12), the display control means 100 stores the ID information of the device information supplying image 70c in the display image storage means 97 and thereafter notifies the notified device name to the text display means 105 (step 1209). Subsequently, the processing is returned to the step 1202. By the way, in a case where a plurality of texts are registered in the text storage means 108 in correspondence with the respective states of the device, the device name and the state of the device are notified at the step 1209.

The text display means 105 having received the notification of the device name reads out the text information registered in correspondence with the notified device name, from the text storage means 108 (step 1501 in Fig. 15). Subsequently, it creates the device information supplying image 70c in which the particular text

information is indicated in the text display area 15, and it displays the created image on the display screen 70 (step 1502). Thereafter, it accepts the input of the instruction based on the touching of the system diagram selection area 12e, through the input means 6 (step 1503). Lastly, it notifies the instruction for displaying the system diagram display image 70b, to the display control means 100 (step 1504). Then, the processing is ended. By the way, in the case where the state of the device is also notified together with the device name at the step 1209 in Fig. 12, the text registered in correspondence with the notified state of the device (any of the normal state, the minor failure and the major failure) is read out at the step 1501.

d. Display of Trend Graph Image

If the content of the instruction designates the display of the trend graph image 70d (step 1210 in Fig. 12), the display control means 100 stores the ID information of this image 70d in the display image storage means 97 and thereafter notifies the notified device name to the trend graph display means 104 (step 1211). Subsequently, the processing is returned to the step 1202.

As shown in Fig. 16, the trend graph display means 104 having received the notification of the device name reads out the state variable data of the state variable sorts in the combination stipulated in correspondence with the

notified device name, from the state variable storage means 109 (step 1601). Subsequently, it creates the trend graph image 70d by the use of the read-out state variable data, and it displays the created image on the display screen 70 (step 1602). Thereafter, it accepts the input of the instruction based on the touching of the system diagram selection area 12e, through the input means 6 (step 1603). Lastly, it notifies the instruction for displaying the system diagram display image 70b, to the display control means 100 (step 1604).

e. Display of Trip Data Image

If the content of the instruction designates the display of the trip data image 70e (step 1212 in Fig. 12), the display control means 100 stores the ID information of this image 70e in the display image storage means 97 and thereafter commands the trend graph display means 104 to display the trip data image 70e (step 1213). Subsequently, the processing is returned to the step 1202.

As shown in Fig. 17, the trend graph display means 104 commanded to display the trip data image 70e reads out the state variable data held in the trip data save means 110 (step 1701). Subsequently, it creates the trip data image 70e by the use of the read-out state variable data, and it displays the created image on the display screen 70 (step 1702). Thereafter, it accepts the input of the instruction based on the touching of the selection area 12, through the

input means 6 (step 1703). When the trend graph display means 104 has accepted the input of the instruction based on the touching of the system diagram selection area 12e (step 1704), it notifies the instruction for displaying the system diagram display image 70b, to the display control means 100 (step 1705), and it ends the processing. On the other hand, when the trend graph display means 104 has accepted the input of the instruction based on the touching of the trip data deletion selection area 12f (step 1706), it notifies the instruction for initializing the trip data, to the display control means 100 (step 1707), and it ends the processing. In a case where the instruction is neither for displaying the system diagram display image 70b nor for initializing the trip data (step 1706), the input is an error. Therefore, the trend graph display means 104 returns the processing to the step 1703 so as to accept an input again.

(3) Display Color Alteration Processing

Next, there will be explained display color alteration processing (steps 1214 - 1217) which is executed in the case of input from the failure detection means 103.

The display control means 100 having received the notification of the occurrence of the failure from the failure detection means 103, searches the display image storage means 97 for the ID information of the monitoring menu image 70a. If this ID information is held (step

1214), the monitoring menu image 70a is currently being displayed on the display screen 70. Therefore, the display control means 100 commands the monitoring menu display means 101 to display the monitoring menu image 70a (step 1215), and it returns the processing to the step 1202. The commanded monitoring menu display means 101 re-displays the monitoring menu image 70a owing to the steps 1301 - 1304 in Fig. 13 as described before. The display color information held in the system-name display color storage area 1112 of the system table 111 has already been updated by the failure detection means 103. In the re-display, accordingly, the system name display area 14 of the monitoring menu image 70a is displayed in the display color which is indicated by the updated display color information.

If the ID information of the system diagram display image 70b is held in the display image storage means 97 (step 1216), the display control means 100 commands the system diagram display means 102 to display the system diagram display image 70b (step 1217), and it returns the processing to the step 1202. The commanded system diagram display means 102 re-displays the system diagram display image 70b owing to the steps 1401 - 1412 in Fig. 14 as described before. The display color information held in the display color storage area 1123 of the device table 112 has already been updated by the failure detection means

103. In the re-display, accordingly, the system name display area 11 of the system diagram display image 70b is displayed in the display color which is indicated by the updated display color information.

(4) Trip Data Initialization

Next, there will be explained trip data initialization (step 1218) which is executed in a case where the instruction for initializing the trip data has been notified by the trend graph display means 104.

The display control means 100 having received the notification of the trip data initializing instruction at the step 1202, stores the initial values "0's" in the trip time storage area and trip flag storage area which are the temporary storage areas reserved in the main storage 91, and in all the storage areas of the trip data save means 99 which are reserved in the external storage 93, as the trip data initialization (step 1218). Subsequently, the means 100 returns the processing to the step 1202.

E. Effects of This Embodiment

According to this embodiment, the constituent system undergoing the failure and the degree of the failure can be readily known from the background color of the system name display in the monitoring menu 70a. Besides, in this embodiment, the system diagram display image 70b which contains the system diagram of the constituent system displayed in the system name display area 14 of the

monitoring menu 70a is displayed in response to touching of the system operator with this area 14, so that the device undergoing the failure and the degree of the failure can be readily known from the background color of the device name display.

Moreover, the device information supplying image 70c which contains the explanation of the device displayed in the device name display area 11 of the system diagram display image 70b and the method of coping with the failure of the device is displayed in response to the touching of this area 11. Besides, the trend graph which indicates the time variations of the values of the state variable displayed in the state variable display area 17 of the system diagram display image 70b and the state variables relating to the first-mentioned state variable are displayed in response to the touch with this area 17. Thus, according to this embodiment, the various information items necessary for the judgements on how to deal with the failure are immediately supplied, so that the system operator can quickly grasp the situation of the failure and can readily select the method of coping with the failure.

Further, in this embodiment, when the trip has occurred in the plant 21, the state variable data for 40 seconds before and 20 seconds after the time point of the detection of the occurrence are saved in the external storage 93, and the saved data can be displayed as a graph,

so that the analysis of the cause of the failure after the trip can be supported.

According to the present invention, the position of a point causing a failure, the situation of the failure and a method of coping with the failure can be known with ease.

Claims:

1. A support system for the failure analysis of a plant, comprising an image display unit which includes a display screen, and a control unit which causes the image display unit to display an image on the display screen;

the control unit including:

means for accepting state variable data which indicate states of devices belonging to constituent systems of the plant;

monitoring menu display means for displaying a monitoring menu which is a list of the constituent systems of said plant, on said display screen; and

failure detection means for judging if any of the devices has failed, on the basis of the state variable data;

the monitoring menu display means being furnished with means for highlighting the system to which the device, judged as having failed by the failure detection means, belongs.

2. A support system for the failure analysis of a plant, comprising an image display unit which includes a display screen, and a control unit which causes the image display unit to display an image on the display screen;

the control unit including:

means for accepting state variable data which indicate states of devices belonging to constituent systems of the plant;

means for accepting selection of any of the constituent systems;

system diagram display means for displaying a system diagram of the selected system on the display image; and

failure detection means for judging if any of the devices has failed, on the basis of the state variable data;

the system diagram containing a display of said devices which belong to said system indicated by said system diagram;

the system diagram display means being furnished with means for highlighting the device which has been judged as having failed by the failure detection means.

3. A support system for the failure analysis of a plant as defined in claim 2, wherein:

said control unit further includes monitoring menu display means for displaying a monitoring menu which is a list of said constituent systems, on said display screen;

the monitoring menu display means being furnished with means for highlighting said system to which said

device judged as having failed by said failure detection means belongs;

the system selection acceptance means deciding the selection of any of said constituent systems designated to be displayed by an instruction, when it has accepted the instruction for displaying the constituent system in the monitoring menu.

4. A support system for the failure analysis of a plant, comprising an image display unit which includes a display screen, and a control unit which causes the image display unit to display an image on the display screen;

the control unit including:

means for accepting selection of any of devices which belong to constituent systems of the plant; and

text display means for displaying predetermined text information in accordance with the selected device on said display screen.

5. A support system for the failure analysis of a plant as defined in claim 4, wherein said control unit further includes:

means for accepting state variable data which indicate states of the devices belonging to the constituent systems of said plant;

means for accepting selection of any of said constituent systems;

system diagram display means for displaying a system diagram of the selected system on the display image; and

failure detection means for judging if any of said devices has failed, on the basis of the state variable data;

the system diagram containing a display of said devices which belong to said system indicated by said system diagram;

the system diagram display means being furnished with means for highlighting the device which has been judged as having failed by the failure detection means;

the device selection acceptance means deciding the selection of any of said devices designated to be displayed by an instruction, when it has detected the instruction for displaying the device.

6. A support system for the failure analysis of a plant, comprising an image display unit which includes a display screen, a control unit which causes the image display unit to display an image on the display screen, and state variable storage means for holding state variable data therein;

the control unit including:

means for accepting the state variable data which indicate states of devices belonging to constituent systems of the plant;

means for saving the accepted state variable data and holding the state variable data, in a way associated with sequence of time in the state variable storage means;

means for accepting selection of any types of state variable data; and

trend graph display means for reading said state variable data of the selected type out of said state variable storage means and then displaying the read state variable data on said display screen.

7. A support system for the failure analysis of a plant as defined in claim 6, wherein the trend graph display means displays said state variable data as a graph.

8. A support system for the failure analysis of a plant as defined in claim 6, wherein said control unit further includes:

means for accepting selection of any of the constituent systems;

system diagram display means for displaying a system diagram of the selected system on the display image; and

failure detection means for judging if any of the devices has failed, on the basis of said state variable data;

the system diagram containing a display of said devices which belong to said system indicated by said system diagram, as well as said state variable data of said devices;

the system diagram display means being furnished with means for highlighting the device which has been judged as having failed by the failure detection means;

the state-variable-data-type selection acceptance means deciding the selection of any of the state variable data types designated to be displayed by an instruction, when it has detected the instruction for displaying the state variable data type.

9. A support system for the failure analysis of a plant, comprising an image display unit which includes a display screen, a control unit which causes the image display unit to display an image on the display screen, and trip data save means for holding state variable data therein;

the control unit including:

means for accepting an external instruction;

failure detection means for judging if any major failure has occurred, on the basis of the state variable data;

means for saving said state variable data accepted thereby during a predetermined time period before and after a time point at which the major failure has been detected, and holding said state variable data, in a way associated with sequence of time, in the trip data save means; and

trend graph display means for reading said state variable data out of said trip data save means and then displaying the read state variable data on said display screen, in compliance with the instruction.

10. A support system for the failure analysis of a plant as defined in claim 9, wherein the trend graph display means displays said state variable data as a graph.

11. A support system for the failure analysis of a plant as defined in claim 9, further comprising:

an external storage;

said trip data save means being located in the external storage.

12. A method wherein a plant having at least one constituent system which includes at least one device is managed by a failure-analysis support system comprising an

image display unit which includes a display screen, and a control unit which causes the image display unit to display an image on the display screen;

the control unit including:

means for accepting state variable data which indicate states of the devices;

monitoring menu display means for displaying a monitoring menu which is a list of the constituent systems, on said display screen; and

failure detection means for judging if any of said devices has failed, on the basis of the state variable data;

the monitoring menu display means being furnished with means for highlighting the system to which the device judged as having failed by the failure detection means belongs;

information of a failed point being obtained by referring to said display screen.

13. A support system for the failure analysis of a plant substantially as herein described and with reference to the accompanying Figs. 1 and Figs. 3-19.

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.N): G4N: NDAL, NHNP, NHX

Int Cl (Ed.6): G08B 19/00, 23/00

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB2271656A	(CLOOS)	
X	US4988996	(ITO)	1,12
X	US4749985	(CORSBERG)	1,12

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